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LECTURES

ON THE

CLINICAL USES

OF

ELECTRICITY.

DELIVERED IN

UNIVERSITY COLLEGE HOSPITAL.

BY

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PREFACE

TO THE SECOND EDITION.

These Lectures were delivered during the summer of 1870, in University College Hospital. They were printed in *The Lancet*, from reports taken in shorthand by my friend Dr. Gowers; and were revised and published in a separate form, in compliance with a request made to me by many of my present and former pupils. They have been again subjected to revision; and I have made such additions to them as appear to me to be desirable, bearing in mind the object for which they were written. It was and is my endeavor to render them strictly practical, by avoiding all trespass upon debatable ground, and confining my remarks as closely as possible to ascertained facts with regard to the clinical uses of electricity in the diagnosis and treatment of disease.

38 Grosvenor Street, Grosvenor Square,
October, 1873.

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LECTURES

ON THE

CLINICAL USES OF ELECTRICITY.

I. GENERAL REMARKS ON THE CLINICAL USES OF ELECTRICITY.

GENTLEMEN: The clinical uses of Electricity, to which in these lectures I shall strictly confine myself, are twofold: electricity may be employed as an aid in *diagnosis*, and it may be used for the purposes of *treatment*.

First, I will say a few words to you generally, with regard to these two uses, and afterwards I shall deal with them in detail.

In respect of the *diagnostic* use of electricity, I want at the outset to guard you against a misapprehension. Electricity in one class of its uses can help you in diagnosis only up to a certain point; all that it will sometimes enable you to say is that there is something definitely wrong. You examine, for instance, the lower

limbs of a patient, and you find a distinct difference between the right leg and the left. In the one the muscles act perfectly when you apply an electric current—no matter which form of current at this moment—while in the other they do not act. From this observation you may infer, and quite apart from the patient's statement, that there is something positively wrong. So far, then, electricity may help you. But do not make the mistake of supposing that all is right because you find no electrical difference between the limbs. That would be an unfair inference; but it is one which has been so often drawn that I must at the onset caution you against it. Now and then you may find the electric condition perfectly symmetrical in the two arms or the two legs, and yet there may be something very grave the matter with one of those arms or legs. When there is a peculiar kind of malady present, electricity may help you to discover that, and enable you utterly to eliminate one thing—"sham;" but you are not to infer that the patient is a malingerer, because you can detect no electric difference between two limbs, one of which he says that he can move, while he asserts that he cannot stir the other.

Again, with regard to *treatment* by electricity I have a few general remarks to make. You can sometimes actually and immediately cure a patient. There are cases in which the only symptom that may be presented to you—I do not say the whole morbid condition, but the only symptom—is loss of voice. Sometimes one

single application of electricity will remove it completely, and in that instance you do apparently *cure* the patient. There are other diseases which you cannot be said to cure, but which you may *relieve* by electricity. By its application you may, in many instances, again and again relieve pain; you may in like manner, relieve spasm; or you may slowly diminish, and even ultimately remove, paralysis. In these cases you assist, by electricity, the processes which lead to the removal of the pain, paralysis, or spasm; you put the patient, by electrical appliances, into a better position to improve, or be cured by the agencies of food, medicines, rest, and time. Thirdly, there is a group of cases in which though you cannot cure, or even relieve, the symptoms, you may yet *arrest* the progress of disease. Sometimes, for example, in a child with so-called "essential paralysis," you may prevent deformity, though you cannot cure the paralysis. In certain cases of lead poisoning, muscular atrophy, &c., although you cannot recall the muscular substance, you may prevent any increase of the atrophy. Lastly, there are some cases in which you can do no good whatever, and in which you may do harm.

The general facts which I wish you therefore to bear in mind with regard to the two main directions in which electricity is useful, are these: that, like other modes of examination or of treatment, this one has its limits, and that only by its appropriate employment

within these limits, can it be of real service in either diagnosis or therapeutics.

II. FORMS OF ELECTRICITY IN CLINICAL USE.

Before speaking to you about the kinds of diseases in which you may use it, and the modes in which you must apply it, I think it is necessary for me to say a few words, as briefly as possible, about the several forms of electricity which are now in common clinical use. You constantly hear of "faradization," "electrification," "galvanism," and so on; of "battery current," "continuous current," and the like; and it is probable that some of you may not have perfectly clear ideas as to the meaning of these terms, or at any rate, ideas which are precisely the same as mine, and I should like us to have a common starting-point, in a clear comprehension of the meaning of the words we use.

Many years ago it was the therapeutic fashion to put the legs of patients into buckets of torpedoes, or electric eels; but this practice, together with many others, has become obsolete, and there are now only three forms of electrical appliance in common clinical use. A. One is that of the old-fashioned "electrical machine," either a cylinder or plate of glass, which, by friction, produces a certain amount of electrical disturbance, one of the results of which you collect on an insulated piece of brass called a "prime conductor."

This is the oldest form of applied electricity, which is still in force in our hospitals. In the present day it is sometimes called "static" electricity; and in speaking of the use of static electricity, what is meant is that the person is "charged," like that "prime conductor," with electricity of that particular kind. It has also been called "frictional" electricity, from the mode of its production; and also "Franklinic" electricity, or "Franklinism," in memory of the individual who—I will not say discovered it, but who—made out more about it than any one else at the time that he worked at the subject.

1. There are three modes in which that electricity is applied. One is simply to make the patient, as it were, a part of the prime conductor, and charge him full of electricity. This is sometimes called the "electric bath." You insulate your patient by placing him upon a glass-legged stool or sofa, taking care that he is not in contact with any conducting substance; then you connect him by a brass chain, by his own hand, or by any other mode you like, with the prime conductor; you set the machine in action, and charge him with electricity, doing nothing more. That is the simplest mode of applying static electricity. In certain diseases it is curious what this will do, without putting the patient to the least discomfort. Probably the only thing he will be conscious of is that his hair seems to be "standing on end;" this is neither painful nor even uncomfortable, but it is won-

derful how much that simple "charging" a patient will effect in some forms of disease. I have known it absolutely remove, in a few seconds, a "tic" that had lasted for days. Pain in the sciatic nerve, many odd and disagreeable sensations, unpleasant flutterings about the heart, depending upon weak innervation, and tremor of the limbs, may be all removed by simply "charging" the patient.

2. Another mode of using this franklinic electricity is to apply a "spark" to a particular part. You may have a movable, insulated brass knob in connection with a prime conductor, and you direct it to the larynx, or some other part, and let the spark go into the skin. Or you may put the patient on a glass-legged stool, and charge him or her in the way I have described, and take a spark out of the larynx or the limb with your knuckle or with a rounded metallic knob. In some cases of aphonia, where the aphonia depends on a special condition, you may insulate the patient and charge him with electricity without the slightest benefit; but take a spark out of the larynx, or put a spark in—whether positive or negative it matters not—and that particular condition of aphonia may be cured directly. This I have known to occur when much more painful processes of electrification had been previously tried, and without effect.

3. A third mode of using franklinic electricity is that of sending the "shock" from a charged "Leyden vial" through the part that you wish to affect. This

has occasionally produced curative results when other modes have failed; and it is in obstinate nervous aphonia that its influence has been the most distinctly seen. But, short of being hanged, I do not imagine that anything could be much more unpleasant.

B. The next form is what has been called Galvanism. It is the form of which one hears so much, in the present day, under the name of the "continuous current," "constant current," or "battery current," or, as it has been sometimes called, with a curious misuse of words, the "interrupted continuous current." By all these terms is meant that form of electricity which is developed by chemical decomposition. The particular form of battery does not matter, so far as the quality of the electricity is concerned. Wherever you have chemical decomposition in progress, there also is some electrical change going on; and the only object a medical electrician has, in choosing any particular form of battery, is to catch the electricity as best he may. This form of electricity is characterized by the following features. It is of relatively low "intensity," so far as regards its action upon nerve and muscle, but it is in considerable "quantity," and it produces "chemical" results and results on temperature, "thermic" results, that are not approximated by the franklinic electricity.

I am not now going to describe to you the batteries, of which there are numberless kinds. The choice among them is guided chiefly by considera-

tions of cheapness, portability, the ease with which the machine can be kept continuously in order, the constancy of the current, the bulk of the battery, and the readiness with which its strength of action can be regulated. What you want is a current that shall play evenly, and at a measurable strength for a certain length of time. It is convenient to have a battery that is portable, and it is a great point to have one that does not require constant supervision. The battery (Elliott's) in our electrical room in this hospital is not portable, but the majority of our patients are; and we have, for use in Wards 3 and 4, a similar battery, placed on castors so that it can be brought to the bedside of the patients. It will act very steadily for three or four months; it can be very readily put in working order by a person who does not need a great amount of electrical skill; and you can easily regulate the strength of the current you employ. The constant batteries of Weiss and Stöhrer are easily portable, and their strength may be regulated with the greatest nicety.

1. There are two modes in which this kind of electricity, or galvanism, is used. In one of them the current is "continuous," in the other it is not. A really *continuous* current may be passed through the body, or part of the body; and this is accomplished by introducing the whole or a portion of the human body into the circle of the battery, and then letting the current play through it. This will do the follow-

ing things: it will relieve spasm of certain kinds; it will relieve pain of certain kinds, and this sometimes in a few seconds, and the effect is as obvious and distinct as is that following the administration of an emetic. A person may have a particular kind of headache; you pass a continuous current, as it appears, through his head, and sometimes in a few seconds the pain is gone. It will also remove some forms of tremor and of spasm.

I want you now to bear in mind certain points respecting the effects of the continuous current upon the limbs, according to the direction in which it is passed through those limbs. Supposing I have the positive end of the battery connected with a person's left hand, and the negative end connected with his right, the current passing from the positive to the negative pole goes up that person's left arm to the trunk of the body, and down the right arm to the machine again. The current passing up the arm has been called the "inverse," and that coming down the arm has been called the "direct." In the arm in which the current is passing upwards the "irritability" of the muscle and nerve is gradually increased; in the other arm, in which the current is passing downwards, the irritability, is gradually diminished. I shall hereafter explain to you the meaning of the term "irritability;" at present remember simply the fact that by now and then breaking and remaking the continuous current, you will find in the two arms two different degrees of

irritability, according to the direction in which the current has been passing, whether up or down. The nerves and muscles of the one arm act more, those of the other less readily than in health. The difference thus produced between them is sometimes highly marked.

It may occur to you to ask, "If that be the case, what current should I use to relieve pain and spasm, the direct or the inverse?" All I have to say is, that, so far as I have seen, it does not make the smallest difference. Theoretically it should make a very great difference, but practically, so far as my observations extend, it makes none. I have seen pain or spasm relieved as well by the current in one direction as in the other, and this whether the spasm has been clonic or tonic, or whether there has been merely tremor.

The continuous current, when weak, produces little or no pain. The patient feels nothing, or next to nothing. If it be strong, he feels a tingling or burning at the points of contact, and a sensation of tightness and tension, in the part between the points of contact, that is very disagreeable, or, when the current is very strong, intolerable.

2. Another mode of using the battery current is by *interrupting* it—making it not continuous. This may be done in various ways. You may take the two sponges attached by wires to the two ends of the battery, place one sponge on the upper part of the man's leg, and interrupt the current by occasionally dabbing the other sponge on the leg at a more or less distant

point. By that means you "make" and "break" the current. Or you may slowly move one of the sponges along the surface of the skin, thus effecting the same object with different portions of the limb. Or you may have a simple piece of apparatus attached to the battery—a cogged wheel, with alternating conducting and non-conducting materials; which wheel can be rotated, and so interrupt the current, while the sponges are maintained in place. Or you may use a little vibrating wire, which makes and breaks contact rapidly, as in one of Pulvermacher's interrupters. In thus applying the battery current you will notice this further fact—namely, that the "direct" application produces more obvious effects upon the muscles—*i. e.*, induces a more marked contraction, than does the "inverse" or "indirect." You will find, for example, that an interrupted battery current—say of ten cells—which when sent *down* the arm produces distinct contraction of the muscles, may elicit no contraction, or very much less contraction, when it is sent *up* the arm in the opposite direction. It is important to bear this in mind when thus using galvanism for the purposes of either diagnosis or treatment, as I shall hereafter show you.

C. The third form of electricity is "faradization" or "faradism." It has also been called "induced" electricity, "magneto-electric," "voltao-magnetic," "voltao-dynamic." When you hear used any one of these words, you will understand by them that particular kind of electricity of which Faraday was the

great exponent. It is electricity of very high tension, and resembles franklinic electricity more closely than it does the galvanic current. The chemical action of faradization is almost *nil;* the direct effect on temperature is almost *nil;* it causes no burning feeling, no sensation of heat, like that which is communicated by the galvanic current; but, under ordinary circumstances, it produces marked contraction of the muscles, and a powerful action on the nerves of both motion and sensation. It is an "induced" current, and is of momentary existence only; but these momentary currents may be repeated slowly or repeated quickly. It exists only at the moment of making or breaking the galvanic current, or at the moment of making or unmaking a magnetic condition in a piece of metal; but it may be made or broken so rapidly that you may pass very many currents in a second of time in both directions. Remember, lastly, that though it is of momentary duration, it is of very high tension.

There are two terms used commonly about it, and which you may see on batteries of various kinds,—"primary" and "secondary." It is for clinical purposes an almost useless distinction. The difference between the two has been said by some to be this,—that the primary will have a more distinct action upon one set of nerves, and the secondary upon another. There are, certainly, some conditions of paralysis in which the primary current is found to act more distinctly than the secondary upon the affected muscles.

But the most marked physiological difference that can be seen between them is that the secondary is of greater intensity than the primary, and will sometimes proceed more deeply into the parts you wish to affect. It is an unhappy use of the word "primary," for the current so named is not a primary current in the sense of being a simple battery current; it is essentially an induced current, or a battery current strengthened by induction. The other is an induction from an induction, and is "secondarily" induced, and the clinical difference between them is mainly one of intensity. If, then, you apply the terms "primary" and "secondary" to faradization currents, remember that you should mean by *each* of them "induced."

The battery which is constantly employed in this hospital, and is found the most useful for clinical purposes, is that known as Stöhrer's. With proper care, and but little trouble, it acts well for many months; it can be put in action or out of action very readily; and its strength may be regulated with the greatest ease. An ingenious apparatus has recently been contrived by Messrs. Mayer and Meltzer, which can be made to yield either a constant current, or an induced current at pleasure.

Those, then, are the three principal forms in which electricity is employed in medicine. It is important for you to recognize them, and to know which form is employed; for if you read the histories of past experiments you will find much diversity in the results that

were obtained, some of which is to be explained by the fact that machines of different kinds were used in the experiments performed.

III. CLINICAL EFFECTS OF ELECTRICITY.

The next question to which I wish to address myself is this,—What can electricity do? This depends very much on its form and the mode of its application. I will first mention briefly what it can do chemically, and then speak of its peculiar or so-called "vital" action on the nerves, muscles, skin, and other tissues.

(A) *Chemical Effects.*—These can be easily seen by the application of a continuous current. You can dissolve the skin, you can coagulate the blood, and you can use a wire, heated by electricity, as a cautery. It has been used occasionally in the attempt to dissolve calculi, but there is not evidence enough to show that it is of much practical value in this direction. It has been used to promote the coagulation of blood in aneurismal tumors, and there are facts which show that it may produce a change in the quality of the blood. At all events, you can make a blister on the skin by its means; but there are many ways of making blisters much more readily. These clinical uses of electricity come rather into the province of the surgeon than of the physician, and I will not occupy your time now by their further consideration.

(B) *Vital Action.*—It is for its so-called "vital" effects—*i. e.*, for its influence on "vital" function—that electricity is being constantly employed. I use the term "vital" to denote certain changes of condition in certain tissues, which we cannot as yet explain by what we know of the ordinary "physical" forces; such as the contraction of a muscle, the circulation in a limb, the sensation of pain, and so on. These vital effects are seen in nerve, muscle, skin, and vessel.

1. *On Nerve.*—Electricity may put a nerve into action, whether that be a motor or a sensory nerve. If the nerve retain its vitality, its own proper function may, by electricity, be called into activity. That is one of its actions on nerves. Its other effect is to diminish the activity of a nerve when that activity is either normal or in excess.

How are these effects on nerves to be produced? Speaking generally, you may call a nerve into action, whether sensory or motor, by franklinic electricity—*i. e.*, by sparks and by shocks; by the galvanic current, used with an interrupter; and lastly, and most readily, by faradization. If, *e. g.*, we have insensibility of the nerves of the skin, as we had in a case in Ward 3 the day before yesterday, we can often remove that insensibility by faradization. In that case the patient did not feel the application of a hot iron, or pinching, and at first did not feel the application of faradization from one of Stöhrer's batteries; but in a very few minutes the sensibility returned up to a certain point; and

to-day it appeared to me to be normal. On the other hand, when the activity of a nerve is too great, and this overactivity displays itself by spasm, by tremor, or by pain, you may reduce that overaction by applying electricity in either of three ways. The most efficacious of these is the application of the continuous current; but you may produce a similar effect in some instances by faradization, and in others by static electricity. I have seen the sensibility, motility, and circulation completely destroyed in a finger and thumb by the (accidental) discharge through them of a battery of twelve large Leyden vials. To the modes in which you should employ these agents I shall return hereafter.

2. *Muscles.*—To the electrification of muscles similar statements will apply. If you want to put into action a muscle which is in a state of morbid inactivity, from either some wasting of its own substance or some nervous weakness, you must apply, not a continuous but an interrupted current. It may be a faradic or a galvanic current, the latter being interrupted by your hand, or by some mechanical contrivance. Where, on the other hand, muscles are contracting preternaturally, exhibiting spasm, either tonic or clonic, you may reduce this action by the continuous current, and also by a very rapidly intermitting faradization. The electricity, from whatever source obtained, may be applied either to the bodies of muscles, through the skin; or to groups of muscles, or indeed single muscles, also through the skin, but by the nerve-trunks which pass

to them; or to groups of muscles, through the skin and nerve-trunks, but by a reflex action of the spinal cord.

3. *Skin.*—You want sometimes to alter the vascularity of the skin, and this you can do by either of the forms of electricity that have been described. You often see, in a partially paralyzed limb, that the tips of the fingers, and sometimes the hands, are of a bluish color—that the nails are dark, and the hands are cold. You may put them in warm water and make them warm, without doing much good, for the hands again become very soon cold and blue; but you can warm them with a continuous current very rapidly, and much more persistently. Sometimes, in the course of a very few minutes, you will find that the blue tint has completely passed away, and that the limb has become warm, and that the sensibility of the skin diminished before, returns to its natural state. I have lately seen two highly interesting cases illustrating the effect of galvanism upon the vessels. In one there had been, for many months, dusky blueness of the fingers and hands, the result of cardiac disease and vascular change; but this color was removed by one application, and has not since returned. In the other, a similar discoloration had persisted, after an attack of erysipelas, in a paralyzed limb; but it was removed as quickly and as permanently.

The application of electricity, in the form of the continuous current, will sometimes do very much more

than this. It will produce a similar effect upon the tissues lying under, and thus you may improve the nutrition of the muscles, and possibly also of the nerves.

The next best mode of relieving the state of low vascular tone in the skin is by applying franklinic electricity, taking sparks from, or letting them pass into, the part. They sting the skin smartly, often restore its color, and, as you may easily see, redden the skin of your own knuckle, if you employ that as your spark conductor.

Faradization to the skin will produce similar effects; and if you wish merely to stimulate the skin, the best plan is to use a metallic brush. In this way you pass into the skin a great many tiny sparks, and produce a similar effect to that of franklinic electricity.

Those curious patches of pigment which accompany migraine, or other neuralgic affections, which "come and go," are often present in pregnancy, and are seen sometimes on the forehead, or underneath the lower eyelids, may occasionally be removed in a few minutes by the application of a galvanic current.

4. *Nutrition.*—Another thing that electricity distinctly does is to improve, and that most definitely, the nutrition of some parts to which it is applied. You may distinctly increase the bulk of many wasted muscles, even when the causes of that wasting differ. The muscles may be wasted from degeneration of muscular tissue; from disease, or accidental division of

their nerves; from some blood poisoning; from disease of the spinal cord; or from disuse, the result of mischief in the brain; and in each of these five great categories of wasted muscles you may do something towards improving their condition by means of electricity. Under almost all circumstances, if there be any muscular tissue left, you can put it into action; and, although you may not be able to bring it under the influence of the will, you can prevent its further wasting, and even recall some of its nutrition. Your object is simply to put the muscle into action; but there is a curious difference in regard of the readiness with which you can do this by galvanization and by faradization, in paralysis from different causes. In certain forms of paralysis and wasting you can easily effect this by faradization, in other forms much more readily by the battery current. The forms of wasting paralysis which you can improve the most speedily by the battery current are; (1) those in which the paralysis has come on from exposure to cold—paralysis of superficial origin, such as that which arises in the face, and is called "facial palsy;" that which occurs, in children and in adults, from exposure of a limb to cold, and which is sometimes produced rapidly, and sometimes removed as rapidly: (2) those which may be produced from poisoning by lead, and certain other forms of change in the nutrition and action of muscles related to the conditions known as chlorosis and anæmia: and (3) certain other forms of wasting paralysis,

for example, the so-called "essential paralysis" of children, the precise origin of which is not yet quite understood. In these forms of disease the nutrition of muscles speedily becomes impaired, and this wasting is only in part, certainly not wholly, from disuse; for muscles may be paralyzed under other circumstances for a longer time, and as profoundly as under these, and yet not waste so rapidly.

Under these conditions of wasting, the nutrition of the muscles may be restored by any form of electricity which will put those muscles into action; but this result is achieved more quickly by the interrupted battery current than by any other. This curious fact you may see again and again, that an amount of faradic force which will act strongly on a healthy muscle will not act on muscles paralyzed in the manner I have described; but that a weak current coming from a simple galvanic battery slowly interrupted will act on those muscles to a degree which is more marked than that which you will observe in health. This is a very curious point, and one that is more than curious, for it is very useful in therapeutics. For instance, if a person comes to you paralyzed on one side of his face from cold—*e. g.*, from sitting in a draught—unable to close his eye, and the mouth fallen on one side, if you take a current from a battery of low power, ten cells or so, you will make the muscles flicker when you put it on, making and breaking the current slowly with your finger or with a wet spouge; whereas if you apply it to

the healthy side, you will perhaps see no effect whatever. The muscle paralyzed here appears to be more sensitive than that which is not paralyzed. If you apply faradization, however, in this condition to the paralyzed side, you see no effect; apply it to the healthy side, and you make the man grimace directly.

There are reasons for thinking, as I have often shown you, that the want of response to faradization is due to the momentary duration and rapid interruption of the induced current, and to these conditions only; for if you very rapidly interrupt the battery current—just as rapidly, for instance, as you can do it with one of these interruptors of Pulvermacher's chains, or even with your own hand—the muscles that are paralyzed will not act to the battery current any more than they do to faradization, whereas those on the opposite side will do so. I think it is clear, indeed, that the want of response to faradization is a want of functional activity in the muscle; it cannot appreciate readily the rapidly interrupted current, from whatever source it may be derived. This is pretty clear; we have seen it again and again. But it has not yet been made out why a muscle in this condition should exhibit an excess of sensitiveness to a slowly interrupted galvanization. That it does so is perfectly clear; and when it does so, and its nutrition is impaired, the battery current is that which you should use for its restoration.

There are other cases of wasting paralysis in which

faradization is much more useful than the battery current. Under such circumstances use faradization. The muscles waste, for instance, from disuse in long-standing palsy, the result of cerebral disease ; and here faradization is often the best form of electricity that you can employ. In all cases, what you want to do is to put the muscle into action, and you must use that form of electricity which most readily accomplishes this end. You may divide your cases into two categories ; those which will respond more readily to the one form of electricity or to the other ; and you are to use in each group of cases that mode of appliance which produces the most distinct contraction with the least amount of electric force.

IV. DIAGNOSTIC USES OF ELECTRICITY.

In speaking of the diagnostic uses of electricity, I shall describe the modes in which it may be employed in discriminating between some of those forms of nervous disease which, more or less closely, resemble one another.

But first let me direct your attention to a matter with regard to which I do not think there is always the clearest understanding. I refer to what one means by the terms "electric irritability," or "contractility," and "amount of electric irritability." The words contractility and irritability have been often used to mean

the same thing, and are constantly so employed at the present day. This is, in my judgment, a mistake, for the one refers to the susceptibility of receiving an impression, the other to the capacity for action; but inasmuch as the former can be ascertained only through the latter, the two elements have been confounded, and the terms have been made convertible. There is this further difference between the words, moreover, which should be borne in mind—viz., that we can use both of them with regard to a muscle, but only the latter. "irritability," when speaking of a nerve. In electrical observations of the kind to which I am now alluding, it is often difficult, sometimes impossible, to separate the two elements concerned. A muscle contracts upon the application of the electric current, and in this contraction the nerve element is more or less constantly involved. We speak of the irritability as we find it exhibited by contraction, or the exercise of its function of contractility, and so use the terms interchangeably. It is obvious, however, that the nerve-irritability and muscular contractility are not always augmented or diminished in paralyzed limbs, *pari passu*. A paralyzed muscle may respond more feebly to electricity, when it is communicated to it through its nerve, than does the corresponding muscle of the healthy limb; and yet it may contract much more readily than its fellow when appealed to by percussion. This I have noticed as especially frequent when there is some rigidity of the muscle, but it is met with when

no rigidity is present. In the majority of cases, however, no attempt is made at the distinction between nerve and muscle; and irritability is measured, or guessed at, by the amount of obvious muscular contraction. That limb or group of muscles is spoken of as the more or less irritable which exhibits more or less obvious motion than its fellow, or than the supposed normal limb or individual would do when the current of electricity is applied. In this way, however, two different things have often been confounded—viz., irritability, and power; or readiness of contraction, and force of contraction. In order to test irritability you may take a person who has one of his arms paralyzed; place his feet in a bath in which there is some salt and water; connect this with the positive pole of a galvanic battery, and let the negative pole, at your pleasure, be connected with one or the other of two basins, into which he puts his hands. The current will thus pass up his legs and down one or the other of his arms. Then, as you apply the current to the right arm or the left, you can discover which of those limbs, right or left, will *respond to the lowest power*. Supposing you have a galvanic battery, and you apply the current from five cells, and this produces no effect on the paralyzed limb, but a distinct flicker in the muscles of the non-paralyzed limb, you may infer that the irritability is greater in the latter. In that manner you test the true irritability of the muscle—you ascertain its readiness of response to a low power. If muscle A will act

to a current of five cells, and muscle B will act only to a current of ten cells, then muscle A is more irritable than muscle B. If the muscles of the right arm will act to a current of lower power than those of the left arm, then the muscles of the right arm are more irritable than those of the left. You must remember the difference of strength between the direct and the inverse current; and in testing the irritability of the two arms respectively, be careful not to send the current up the one arm and down the other, and lose sight of that fact in your interpretation of the phenomena. You often find, when applying a strong current of electricity to two limbs, one of which is paralyzed and the other healthy, that the muscles of the latter act much more vigorously than those of the former. You are not, however, to infer from such observation that the muscles so acting are more irritable. They are often less irritable than the others, but they are stronger, and when you put them into action they act more vigorously. In the one case you are testing irritability; in the other you are testing power. To ascertain, then, the irritability of a muscle—*i. e.*, to see how irritable it is, you must reduce the strength of the current you employ, whether faradic or galvanic, to the lowest point that will produce action. With a more powerful current, all that you may show is that one muscle is stronger than the other; for you lose sight of the finer differences of irritability in the obvious presence of the coarser differences of strength.

If we take four or five cells of a galvanic battery, and apply the current, made and broken slowly, to a paralyzed muscle, we often find that it will respond much more readily than will a healthy muscle, because it is more "irritable." But if we take thirty or forty cells, or a faradization machine, we often find that the same healthy muscle will perhaps draw the hand out of the water, while the other (the paralyzed muscle) will merely give a little jerk. The healthy muscle in this case, though less irritable, is more strong. The "amount" of irritability is in inverse proportion to the degree of electric force which is required to bring it into play.

A. Perhaps the most general diagnostic use that can be made of electricity is this: to determine, in a case of paralysis, or loss of voluntary power in a muscle or group of muscles, the cause of that paralysis up to this point, whether it depends upon some condition which shuts off from that muscle the influence of the spinal cord, or whether it be some change which, although it may paralyze the muscle to the will, does not remove the muscle from the influence of the spinal cord. Sometimes it is of very great importance to be able to distinguish between those two conditions, and to recognize that one to which Dr. Marshall Hall applied the term "spinal paralysis." I must therefore occupy your time, for a few minutes, in explaining to you the exact sense in which Dr. Marshall Hall used that term. What he meant by it was, not necessarily disease

of the spinal cord, but the separation of a muscle from that organ. It is clear enough that that separation may occur in two different ways; and further, that disease of the spine may exist, and cause loss of voluntary power, and yet not produce what he termed "spinal paralysis." In considering this subject, it is important to remember these different conditions which may cause paralysis;—a muscle may be paralyzed by something wrong in the tissue of the muscle itself; by something which cuts through the nerve that should connect it with the cord; by something which destroys that part of the cord from which the nerve arises; by something which destroys or cuts across the cord higher up than the origin of its nerve; or by something which damages the brain. Thus, then, there are five different lesions, or rather, localities of lesions, which may produce paralysis.

What Dr. Marshall Hall meant by "spinal paralysis" was the functional separation of a muscle from the cord. And here let me remind you that there is a condition which does not effect this separation, and yet which has sometimes been termed "spinal paralysis." If there be disease of the spinal cord above the origin of certain nerves which supply a group of muscles, there may be paralysis of those muscles to the will, but there need not be any "spinal paralysis," in the sense in which Dr. M. Hall used that term. The paralysis is one depending upon disease of the spinal cord, but the particular nerves and muscles of which I am speak-

ing may still maintain their normal relationship to a healthy portion of the cord, and the muscles under those circumstances may still preserve their normal electric irritability.

There is, in this case, "cerebral paralysis;" the patient is deprived of the use of some of his muscles; the brain and the muscles are, so to speak, cut asunder; they are paralyzed to his brain, but they are not paralyzed so far as the spinal cord is concerned, though the lesion is in the cord itself. But if there be destructive change in the cord, at that particular locality from which the nerves of the supposed group of muscles are given off, the condition of those paralyzed muscles is very different. Regarded merely in relation to the will, they present no difference—they are simply paralyzed; but in the one case they are shut off only from the brain, in the other they lose all that was conferred on them by the spinal cord. Spinal disease exists in both instances, but it is to the latter only that Dr. M. Hall applied the term "spinal paralysis."

There is another way in which spinal paralysis may be brought about—viz., by the division of the nerve between the cord and the muscle, "traumatic paralysis," as it is sometimes called. By a neuroma, or other tumor, or by an accidental injury, a nerve may be damaged or cut through, and then the muscle stands, so far as its electric irritability is concerned, in the same position as in the case where the cord itself is destroyed at the point at which its nerves come off.

The most general principle that I can lay down for you in regard to electric irritability, used as a means of diagnosis, is this,—that when a muscle is simply separated from the influence of the cord, by destruction of its nerve, or by destructive disease of the cord at the origin of its nerve, it loses its electric irritability, it loses it quickly, and it loses it to all forms of electric irritation. The degree of loss or diminution may vary, but it varies directly in proportion to either the amount of interference between the cord and muscle, or to the degree of damage done to the cord itself. The clearest proof of the truth of this statement is to be derived from the fact, that of all the experiments made by Dr. Marshall Hall, and of all the conclusions he drew from them, whether the rest were right or wrong, this particular one has been regarded as correct by those who have the most carefully investigated the question.

(*a*) In simply destructive brain disease there is no diminution in the contractility of the paralyzed muscle to the electric current, and there may be a distinct increase. Dr. Marshall Hall maintained that the increase was habitual, but his assertion has been found to be not invariably correct; and much of the apparent discrepancy between his statements and those of others who differed from him, was due to the fact that Dr. Hall employed galvanism, while others used faradization apparatus; and that Dr. Hall really tested the irritability of tissues; whereas his opponents tested the force of contraction.

(*b*) In spinal disease, which is so situated that it does not destroy or damage certain nerve-fibres which come off below the seat of lesion, and pass to certain muscles which may be paralyzed, there is no necessary diminution of the electric irritability; but there is sometimes a notable increase in its amount, and a great exaggeration of reflex action.

(*c*) Spinal cord disease which simply damages a part of the cord diminishes the electric irritability of the muscles supplied by nerves coming from that portion.

(*d*) Section of a nerve which simply cuts the muscle off from the spinal cord produces a similar result.

(*e*) Injuries or diseases which not only damage either spinal cord or nerve trunk, but which, at the same time, cause irritation of their distal extremities, occasion loss of contractility to faradization, and increase to the slowly interrupted battery current.

B. Another diagnostic use of electricity is seen in the distinction between certain imaginary, fanciful or feigned conditions of paralysis and those which are real. For instance, it has often been said that, in cases of railway accidents, persons sometimes "put on" all sorts of symptoms; and so they do. There is no doubt that many symptoms are deliberately put on. But there are other cases in which people frighten themselves, or are frightened, into believing that there is something much more grave the matter with them than the facts really warrant, and so an injured person

often becomes powerless from ideal influence when not paralyzed by disease; and here electricity may be of service. But the great use of electricity in such cases is this, that if you do find a definite, well-marked difference between the muscles of the two sides, you are justified in inferring that there is something more than mere fancy, something that cannot be feigned. I remember an important case in which a physician and a surgeon in attendance upon a gentleman who was supposed to be paralyzed on one side as the result of a railway injury—although they were his own medical advisers—had grave doubts about the reality of the paralysis. They thought the patient put on or imagined a great deal, and that his paralytic state was more or less fancied, if not actually shammed. The persons on the side of the company said, unreservedly, that there was not a particle of truth in the apparent paralysis—that the patient was no more paralyzed than they themselves were. And I must tell you that there were certain points about the case which led one to infer that the man was to a certain extent affecting some of his symptoms. Now, here came in the electrical test. He could not move his right arm; he dragged his leg after him; he could not pronate or supinate his hand. Some said he could if he liked; but I would defy him to do what I am going to tell you. To his left arm I applied a strong faradization, which knocked his arm round with an amount of pain that made him use

strong language, which I need not repeat. I then applied it to the paralyzed arm, passing the current through the pronators. There was not the slightest movement. Now I do not mean to say that a very strong man might not, by a very strong effort, have kept his hand still; but I am quite sure he could not have prevented from acting the muscle, that was between the two poles of the battery any more than he could prevent his pupils from contracting upon exposure to light. I used the same current several times, and then increased its strength; but there was only the smallest flicker of contraction in the muscles on that side. So with the leg. I applied it to the healthy leg, drew the foot up, and brought forth more exclamations; to the other leg, and the muscles remained perfectly flaccid, without the smallest contraction. Whatever may have been the doubts in that case as to what the man might have "put on," I think we may take it for granted that he could not have put on that; for no man could resist by a simple effort of the will, the action of a muscle to such a current as this. The difference between the irritability of the muscles on the one side and on the other was most striking. I never saw a more marked case. The difference which it made to the man was something very material in the matter of compensation, and thus electricity was used for diagnostic purposes with advantage to the patient as well as to the physician.

Electricity is often of real use as an aid in the diagnosis of paralysis when it forms a part of that complex malady called "hysteria." When the paralysis is of recent date, the contractility of the muscles is unimpaired; but it sometimes happens that the patient does not feel the application of faradism, although it may be strong enough to induce powerful action. When the paralysis has lasted for some time and the muscles have become soft and flabby, there is commonly some diminution of their irritability as well as of their strength; but this diminution is speedily removed by a few applications of a current of moderate strength.

C. Now we have to consider in detail some of the diagnostic uses of electricity.

1. If the contractility of a paralyzed muscle is normal, you may infer this—that it retains its normal relationship to the spinal cord; or, in other words, that the spinal cord, in the particular region at which the nerve of that muscle is given off, is not diseased, and that the nerve between the spinal cord and the muscle is not damaged. The cord may be diseased, so that its conducting power is abolished; or the brain may be diseased, so that the will is separated from the muscle that is paralyzed; but that muscle, although paralyzed, still maintains its normal relationship to the segment of the cord from which its nerves arise, and that segment of the cord retains its central functions.

2. If you find the contractility of the paralyzed

muscle to be increased upon either direct or reflex stimulation, you may infer the same things, but also something more—viz., that there is present an increased irritability of either the nerve, the spinal cord, or brain, commonly due to some increased vascularity of one or the other of those organs. The same conclusion is probably correct when there is diminished irritability to faradization and increased contractility to slowly interrupted galvanism. Take, for example, a case of hemorrhage into the brain. Sometimes immediately after an attack of hemorrhage, if you are rash enough to perform the experiment with electricity, you may find that the irritability of all the muscles of the body is diminished; the patient is in a state of more or less marked shock or collapse. After a little time—a few hours or two or three days—you will find no difference between the muscles of the paralyzed side and the healthy side; they are just alike so far as their electric contractility is concerned. But in a few days more, you may find that the muscles on the paralyzed side act to a lower current than those on the healthy side—*i. e.*, that they are more irritable; and you find this change in them coincident with some headache, giddiness, heat of head, and often with a little tendency to clonic spasm or rigidity in the paralyzed limb. In this case the increase of irritability is, I believe, due to the hyperæmia that sometimes follows such cerebral accidents as hemorrhage, embolism, or the breaking down of a few nerve-fibres from softening.

I do not think that electricity will help you further than this with regard to the diagnosis of cerebral disease. My own observations on this special point have led me to the conclusion that the increase of irritability of paralyzed limbs in cerebral disease is not dependent on the mere locality of the disease—*i. e.*, on the simple fact that the disease is cerebral; that it is not dependent on the time that the disease has lasted, nor on the degree of paralysis present—*i. e.*, whether the muscles are completely immovable by the will or not; that it is not dependent on the extent of paralysis—*i. e.*, whether the whole limb is paralyzed or only a portion of the limb; that it is not dependent on the presence or absence of sensation in the limb; and that it is not dependent on the presence or absence of spasmodic contraction in the muscles. All these may be eliminated as either necessary or constant conditions of the excess of irritability. But when the excess of irritability is present, you often find tonic or clonic contraction of the muscles, and, associated with that, a little headache or heat of head and the other symptoms I mentioned of increased vascularity in the brain-tissue or in its membranes.

The other condition which may lead to increased irritability of a paralyzed muscle is that which you meet with in some diseases of the spinal cord, such as hemorrhage, inflammation, sclerosis, or tumor. For instance, when disease is situated in the upper part of the cord, there may be complete loss of contractility in

the muscles connected with that part, but an augmented irritability in the muscles lower down. Myelitis, or a tumor pressing upon the cord above, may set up a certain amount of irritation, or increased vascularity in the cord or its membranes below; and this leads to an increase in the electric irritability in those muscles connected with the lower portion of the cord. This increase is seen not only in the muscles directly excited, or excited through their nerves, but in groups of muscles, more or less remote, which are made to contract by reflex action. At the same time, you often meet with spontaneous spasmodic movements, an increase of reflex irritability on tickling the soles of the feet, and an increased contractility on percussion. This condition is not permanent, for usually such disease extends downwards, and the contractility eventually becomes impaired.

Sometimes the muscles which have ceased to respond to faradization exhibit energetic contraction when galvanized. To this condition I shall recur immediately. The electric contractility of muscles is sometimes found to be increased when there is no paralysis in the strict sense of the word; but when there is some weakness associated with, and apparently dependent upon pain. In the early period of so-called "locomotor ataxy" there is often an exaggeration of electric contractility, and a similar condition may be observed at the commencement of paralysis agitans. In hysteri-

cal paralysis also the irritability may be either normal or increased.

3. We now come to the consideration of those cases in which the electric contractility is diminished. Several conditions may lead to this diminution. The brain may be diseased, or damaged in such a way that paralysis shall occur, and that eventually the contractility of the muscles shall be diminished. There may be disease in the spinal cord which shall lead to this change very rapidly—there may be disease in the nerve which shall induce it almost immediately—the muscle may be in an altered state of nutrition—or lastly, the blood of the patient may be altered by some toxic agent, so that the electric irritability of nerve-centres, nerves, and muscles is reduced. Electricity may, to a certain extent, help you in distinguishing between these several conditions.

(*a*) When you find, as the result of cerebral hemorrhage, sclerosis, softening, or tumor, that the irritability of the muscles is diminished, the usual explanation is this: that the muscle has lost the whole or part of its irritability from disuse, which may or may not be accompanied by wasting. When this is the case, a few applications of electricity, repeated at tolerably short intervals, will put the muscles into precisely the same state as the muscles on the healthy side, so far as electric irritability is concerned. You bring them into action, and you improve their nutrition. After two or three applications of galvanism or faradization

—it does not matter which—the muscles will contract about as readily as those on the opposite side; but you may go on indefinitely in these cases and not produce the smallest improvement in the paralysis; the muscle does not resume its relation to the will. You simply recall the electric irritability which was in abeyance from disuse. When you cease your applications, you find the patient can move his arm no better; and in a few weeks the muscle again is wasted a little from disuse, and has become somewhat diminished in its electric irritability. When you find that, after several applications of electricity to the limbs that have been paralyzed by cerebral disease, there is no restoration of the contractility of muscles, you are warranted in inferring that disease has extended downwards to the spinal cord.

In some curious cases there is, with partial and incomplete paralysis, a slightly diminished electric contractility and sensibility, a firm, almost rigid, condition of the muscles, and normal or even increased nutrition. Here, the diminution of contractility may be sometimes removed by a few applications of electricity, but no relief is afforded to the paralysis; and subsequent applications effect no other change than occasional increase of reflex movements. These cases are, I believe, examples of diffused cerebro-spinal sclerosis.

(*b*) When the cord itself is diseased, and there is loss of electric contractility, you may find precisely

the same relations to disuse; but you may find, in other cases, that there is loss of power and diminution of electric irritability, which are not due to simple inaction, but to true "spinal paralysis." In these latter cases a few applications of electricity effect no change; but if you go on systematically with galvanism, and attend to the general health, you may, after many months of treatment, find that there is some improvement, or even a cure. It is probable that in these cases, the stimulation of the peripheral ends of the muscular nerves may have some transferred influence on the nutrition of the cord, and may assist in the general process of repair; but when the cord is disorganized, and the paralysis and loss of electric contractility are complete, you can do no good by continued applications. By electricity, therefore, you may speedily decide as to how much of the paralysis is due to disuse; and you may distinguish merely impaired nutrition from actual disorganization of the spinal cord.

(*c*) The third condition of diminished contractility that I spoke of, is that in which the nerve-function is arrested, between the cord and the muscle, by injury, wound, or disease. The most common form in which the effects of this direct injury to a nerve are seen is in the case of "facial paralysis," arising from disease in the ear, or in its neighborhood. You there see true "spinal paralysis" of the muscles supplied by that nerve, just as well marked as if you had divided a

nerve in the arm, and had produced paralysis of the hand. You find a loss of electric contractility, when the nerve-function is completely arrested; or a diminution of that function, varying in degree in proportion to the amount of damage done. If the nerve be pressed upon slightly, there will be a certain amount of power left in the muscle, and there will be a certain amount of contractility retained; but if the nerve be cut across, or so far injured or pressed upon that the will can in no degree influence the muscles, no trace of electric contractility remains. Sometimes there is loss of contractility to faradization, and increase to slowly interrupted galvanization. Here it is probable that the lesion, which has destroyed the conductive functions of the nerve-trunks, has occasioned irritation of their distal extremities. You may apply electricity or galvanism time after time, but you cannot restore to the muscle the voluntary power that it has lost, when that loss depends on division of, or irremediable damage to the nerve. But in certain complex cases, and almost all cases are complex, you may do some good by treatment. For example, a person may have had some disease in the temporal bone, and may have been paralyzed on one side of his face, almost completely. You apply electricity to it, and you find perhaps that there is the slightest flicker of contractility about the muscles of the eyelid and the angle of the mouth. Under such circumstances, continuing the application, you may find that the condition is im-

proved up to a certain point. The eye which was wide open, is more closely approximated by the lower lid, and there is less irritation from dust; but you do not cure the case, and you often find that further applications of electricity do no good. Here, I take it, the condition is analogous to that which I described just now as depending on cerebral or spinal disease. The muscle has become weakened from disuse; it has not altogether lost its function, but it has lost it in some measure. From the shock of the accident, or from disease, it may have been placed at one time beyond the power of the will, and the consequent disuse has brought about changes in its nutrition. The paralysis would be permanent if the case were left to itself; but you may remove all that is due to disuse, and so, by electricity, sometimes place a patient in much pleasanter circumstances than those he was in before. A few applications of electricity will enable you to decide this question—how much of the paralysis is due to disease, and how much to disuse. I remember a man, paralyzed on one side of his face for seven years before I saw him, in consequence of disease in the external ear and parotid gland, which had been set up when he was in Australia. His mouth was excessively deformed. The eye on the one side was always wide open, and he had to wear a big glass to conceal the deformity, and also to protect the eye. A few applications of faradization brought the edge of the lower lid just into contact with the eyeball, but he was never

able to close the eye. Another thing which faradization enabled him to do was to whistle—an accomplishment which, by his paralysis, he had lost; and as he was going out into the wilds of Australia again, it was, as he said, "a great luxury for him to be able to whistle when alone." He was, I think, more grateful for the restoration of his whistling power than even for having the dust kept out of his eye.

(*d*) Sometimes the loss of electric contractility is due to a change in the muscular tissue which may occur primarily; for example, there are cases of wasting and paralysis due to simple exposure to cold, such as certain examples of so-called "rheumatic" paralysis, of facial paralysis, some cases of so-called "essential paralysis" in children or adults, and also "muscular palsy," the result of blood-poisoning. Cases of "essential paralysis" in the child may, I think, be split up into two great groups. There is one which depends upon spinal disease—of which I am not at this moment going to speak to you—but there is another, to which I wish you to direct your attention for a few moments, which comes on from exposure to cold, as, for example, when a child sits down on a cold doorstep, "takes cold," and you find one or both of its lower limbs paralyzed. A similar accident happens when a man sits in a railway carriage and the wind blows upon his face, and one side of his face becomes paralyzed; or when he lies under a hedge and sleeps there through the night, and in the morning finds that one of his

arms—that one which lay upon the wet grass—is paralyzed. In these cases you may discover that a group of muscles is affected in a particular locality, and often that this paralysis bears no relation to any particular nerve or branch of nerve. The lower part of a limb may be paralyzed and not the upper, or *vice versâ;* the middle part of a limb may be paralyzed and the rest may escape. You often find some paralysis of the glutei and the muscles of the thigh, while the muscles of the foot are, all of them, left intact. You may sometimes find that the deltoid is paralyzed, and that there is loss of power of moving the arm backwards and forwards, or upwards and outwards, and yet that the hand retains its power. You may find that the muscles about the elbow are paralyzed, while those of the shoulder and of the hand are unaffected; and in all these cases there is loss or diminution of electric contractility. I do not believe that paralysis of this distribution ever occurs as the result of central disease of the nervous system. In central disease the distribution of paralysis is such that the disease shows itself the most distinctly in the extremities —*i. e.*, at the distal ends of limbs; you find numbness at the tips of the fingers, and not over the shoulder; loss of power in the fingers, and not in the deltoid. Further, when the whole of a limb is paralyzed from central disease, the order of improvement is definite; for example, in the upper extremity, the first place in which power returns is in the shoulder, then in the

arm, then in the hand, and lastly, in the fingers. In this muscular paralysis, which may come on from some change in the nutrition of the muscle itself, you find an irregular distribution of the paralysis and an irregularity in the order of cure. The loss of electric irritability is also irregular, and this may aid you in diagnosis. In these cases, when the muscles are primarily affected so as to produce paralysis, the curious condition may often be noticed that the irritability to a slowly interrupted galvanic current is sometimes distinctly increased. It is greater than that which exists in a healthy limb. But you will find that if you interrupt that current rapidly, the contraction is very much less than that of the healthy limb; and if you take a faradization machine, you may find that the irritability is completely extinct; the muscles in this state will not respond in the smallest degree even to a very high power. In facial paralysis from exposure to cold, in the paralysis from lead, in that of the limbs arising from cold, and also in some anomalous cases of atrophic paralysis of limbs—the precise nature of which I do not think we can state at the present moment—in all these this peculiar relationship may be noticed. Observe, again, what it is. To faradization the muscles act not at all, or much more feebly than they should do. To the rapidly interrupted galvanic current they exhibit precisely the same thing; but if you very slowly interrupt the galvanic current, they exhibit a greater amount of irritability than do the healthy

muscles. The first of these positions was made out by several observers at about the same time; but the second—that with regard to the rapid interruption of the battery current—was observed by ourselves in this hospital, and also by Neumann, of Königsberg.* You

* "Neumann in Königsberg hat zuerst durch vergleichende Untersuchungen nachgewiesen, dass in jenen rheumatischen Gesichtsparalysen, die bei Mangel von faradischer Irritabilität Erhaltensein der galvanischen Erregbarkeit der Muskeln konstatiren lassen, weder die schnelle Aufeinanderfolge verschieden gerichteter Ströme, noch die abwechselnde Richtung selbst zur Erklärung der fraglichen seltsamen Erscheinung hinreichen. Dagegen erwies sich die Dauer der Strome als massgebend. Wurde nämlich der Batteriestrom durch eine Vorrichtung ebenfalls nahezu momentan gemacht so blieb auch bei Reizung durch ihn die Kontraktion aus, während sie regelmässig eintrat, wenn der konstante Strom nur ganz geringfügig, über das Momentane hinaus, andauerte. In späterer Folge hat Neumann auch an ermüdeten Praparaten obiges sonderbares Verhalten gegen die eine und andere Stromesart demonstrirt.

"In neuester zeit hat Prof. Brücke dieselbe Eigenthümlichkeit der elektrischen Erscheinungen auch bei mit Curare vergifteten Präparaten gefunden. Nach vergiftung des Frosches mit Curare (bei unterbundenem Schenkel) zeigt sich, dass zur Erregung des vergifteten Beines stärkere Inductionsströme nöthig sind, als fur das unvergiftete, wahrend bei konstantem Strom, dieselbe Reizstärke wie früher genügt. Dass die Stromesdauer den Unterschied bewirke, zeigt ein anderes Experiment. Nachdem man sich überzeugt hat, dass das vergiftete Bein bei schwächeren Kettenströmen zuckt, als das unvergiftete, lässt man Ströme eines schnell rotirenden Blitzrades in

can immediately alter the relation of the muscle to the galvanic current by a more rapid interruption; galvanism then produces no effect at all, although it will act perfectly on those muscles of the patient which are not paralyzed, and, as many of you have seen, upon your own. This form of disease seems to place the muscles in precisely the same relationship to the rapidly interrupted galvanic current as to faradization; but the fact which I do not think has yet received an explanation is this, that the muscles in this curious condition are oversensitive to the galvanic current when it is interrupted slowly. The explanation may be difficult, but the fact is clear enough. When the irritability of a muscle is diminished to galvanization as well as to faradization, you have some disease present which is different from that I am describing. You will find such cases very difficult to cure; whereas, in the treatment of the former class, the application of slowly interrupted galvanism is rapidly and notably useful, and displays an interesting physiological fact —viz., the gradual reduction of the oversensitiveness of the muscle to that slowly interrupted galvanization, and the gradual return of contractility to faradization

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das Präparat hereinbrechen; der unvergiftete Schenkel verfällt in Tetanus, während der andere in Ruhe verharrt. Es scheint dass diese durch Curare hervorgebrachtete Unempfindlichkeit gegen kurzdauernde Ströme von der Funktionsunfähigkeit der Nerven herrhürt."—*Rosenthal, Wiener Medizinische Presse,* 1868, p. 502.

and rapidly interrupted galvanism. To-day, for example, the muscles will act to five cells of Elliott's battery, and will not respond to a strong current from Stöhrer's; but next week you will find that you require ten or fifteen of the former to produce any result, and that a much lower degree of the latter will induce some flickering contraction. You go on for another week, and you have to employ a still larger number of cells to produce the same result, and at last you find the muscle in the same condition as the healthy one, and then you find that it has regained its ordinary state to faradization. This has been seen so often in cases of lead paralysis, as well as in those which are due to cold, that there is no doubt about the fact, whatever may be its explanation. The oversensitiveness to the battery current is gradually reduced by the application of that current, and the loss of sensitiveness to faradization is gradually brought back as you employ slowly interrupted galvanization.

(*e*) Lastly, the electric contractility is diminished by certain changes in the blood, such as anæmia, chlorosis, and opium poisoning. Here the diminution is moderate in degree, and general in its distribution, is only slightly influenced by electric applications, but is removed surely by the improvement of the general health or the elimination of the poison.

D. Modifications of Electric Sensibility.—There are several elements with which you have to deal—namely,

the skin, the muscles, the nerve-trunks, and the nervous system generally.

1. In health, the application of electricity to the *skin* is accompanied by sensation varying, in kind and degree, in relation to the form and the force of the agent employed. Franklinic electricity, when used in the form of sparks, produces a stinging sensation in the skin, which is painful to some people, but not altogether unpleasant to others. The continuous galvanic current produces two sensations: one, a feeling of burning, which is intense in proportion to the force that is employed, and which is especially felt at the point of contact of the positive pole; the other a sense of heat, tension, and thrill between the poles. Faradization gives rise to a feeling of stinging or burning, in proportion to the intensity of the induction, the rapidity of the interruption, and the dryness of the conductors.

In disease, the electric reactions of the skin may be much changed. The patient may exhibit an increase, a diminution, or an entire absence of sensibility.

(*a*) Increase of sensitiveness is found in many simply "nervous" people, whose sensations are all, more or less, exaggerated. In them, too, you may observe much of the hysterical character, and sometimes it is obvious that the increase of sensibility is due to a central—*i. e.*, to a mental and moral—state, rather than to any peripheral change. But occasion-

ally you find that the skin of one limb is more sensitive than that of its fellow, and usually that this increase is associated with augmented sensibility of the muscles under electric action. The diagnostic value of this change is identical with that of increased electric contractility, so far as the nature of the lesion is concerned, but it may differ from it in regard of the precise locality of change.

(*b*) Diminution of cutaneous sensibility to electricity is met with when there is the condition of "shock" which accompanies recent and suddenly induced paralysis; and at the same time there is, commonly, loss of tactile sense and of the power of appreciating cold and heat. It is also found in some cases of hysteria, apart from any paralysis or other change of motility; and it may exist as a chronic symptom, in some very rare cases of central disease.

2. When the *muscles* are put into action by electricity the healthy individual feels their contraction. If the force employed be of low tension, and only slowly interrupted, the sensation is not unpleasant; but if the current be of high tension, or be very rapidly made and broken, the feeling in the muscles amounts to pain, and, indeed, to very severe pain, of cramp-like character. In health the amount of sensation is in direct proportion to the force of the contraction; but in disease this relation does not

always persist; and, moreover, there are certain states of the nervous system in which both contraction and sensation are together morbidly exaggerated or depressed.

(*a*) Increased electro-muscular sensibility sometimes exists alone. I have found it in the trunk, or in all the limbs, or in only one of them, apart from any general or local increase of contractility. Patients sometimes feel, and feel painfully, an amount of muscular contraction which they would scarcely recognize in health; and this painfulness of muscular movement may be either general or local. It is, when persistent, usually dependent on change in the central nervous system, is accompanied by increased cutaneous sensibility, often by neuralgia, or by other modifications of sensation—pseudæsthesia or dysæsthesia—which are sometimes erroneously termed hyperæsthesia. It is very common, as a temporary phenomenon, in all localities of myalgia, or so-called "muscular rheumatism."

The electro-muscular sensibility may be augmented *pari passu* with the increase of contractility. In such circumstances the muscles act more energetically, and the patient feels that action more acutely than he should do in health. Sometimes this condition is general, and then the only comparison that can be made is between the patient and the average of other men. But when the increase is local, as, in-

deed it often is, the limbs of one side may be contrasted with those on the other. The diagnostic value of such increase is the same in kind as that which I have already described to you when speaking of augmented contractility.

(*b*) The sensibility of the muscles is usually diminished when their contractility is reduced; and this diminution is commonly in direct proportion to that reduction—as, for example, in lead paralysis. But sometimes there is other than this parallel deviation of the two functions from their healthy standard. We meet with cases in which the contractility persists, but in which the sensibility is diminished or extinguished. The muscles act well, but the patient does not feel their action. This peculiar relationship is observed in some cases of hysterical paralysis, but I have also found it in individuals who had exhibited none of the ordinary features of hysteria. On the other hand, it has been found that in rare cases of lead poisoning the sensibility has remained intact when the contractility has been diminished. When contractility, as well as muscular and cutaneous sensibility, are all diminished in a limb or in one-half of the body, the condition is one either of "shock" or of extensive cerebro-spinal lesion; the time during which the symptoms have lasted, and the mode of their onset, will enable you to diagnosticate between them.

3. The *nerve-trunks* appear to be so involved in certain electric applications that sundry sensations

arise from their irritation. When the poles of a galvanic battery are applied to the skin in close proximity to one another the nerve-trunks may escape; but when they are widely separated some nerve-trunks may be involved in the circuit; and then, with the continuous current, there is, in proportion to its strength, a feeling of extreme discomfort—of straining and burning—between the poles, and some sensation of tingling, numbness, or "pins and needles" beyond their points of contact. If, under such circumstances, the current be made and broken, there is a painful feeling of shock at or about the joints which may be traversed. A similarly painful affection of the nerve-trunks may be observed when the conductors of faradization are widely separated. But the most painful of all modes of electrification is that by the Leyden vial, the sudden jar which is given by this mode of application being such as few can bring their minds to bear. A strong shock from a large Leyden vial or from a battery of vials will sometimes completely paralyze nerves of both sensation and motion in the parts through which it has passed. To this I have already alluded, and have quoted a case in illustration.

The application of electricity to the nerves of special sense produces sensations of special kind, such as flashes of light, a phosphoric odor, a saline and metallic taste, or a rumbling noise; and these sensations may be induced either directly or indirectly. Giddiness, faintness, or nausea may be also brought about

by electricity; but the clinical uses of such applications have yet to be discovered.

In some cases of general torpor from cerebral disease or blood-poisoning, and in destructive disease of the spinal cord, and in these alone, do we find marked diminution of electric sensibility in the nerve-trunks, when that function is appealed to in the manner that I have described.

4. The *nervous system*, as a whole, or the cerebral centre of sensation, is in some persons much more sensitive, and in others much less sensitive, than the average. Some people can bear without discomfort a strength of application that would be intolerable to the majority; whereas others cannot endure a degree of electric stimulation that is almost imperceptible by those in health. Such modifications of electric sensitiveness are sometimes found in association with increase or diminution of general nervous impressibility, but this is by no means invariably the case. It is important to bear these facts in mind when using electricity for diagnostic purposes; and any erroneous impression that might have arisen from the discovery of either augmented or diminished sensibility in a particular limb or organ, may at once be corrected or removed by an extended or differential observation.

V. THERAPEUTICAL USES OF ELECTRICITY.

I told you in the first lecture that, by the aid of electricity, you might in some instances *cure* a case—*e. g.*, one of hysterical aphonia; that in other cases you might *relieve* the patient of pain, spasm, and paralysis; and that in some other cases, although you could neither cure the disease nor actually diminish the symptoms, you might prevent their further progress—you might *arrest* the disease.

1. Remembering the objects that we have in view, let me recall to you for a moment what it is that electricity can do, in its several forms, in order that you may understand the better how to apply it to the various conditions of disease.

First, it may call into action, or it may increase the action, of a nerve or a muscle; and this is what you want it to do when nerve or muscle is in a state of inaction or underaction.

Secondly, electricity may reduce, or even annihilate, for a time, the action of a nerve or muscle; and this it is that you may sometimes want to accomplish when a nerve or muscle is overactive. You can, therefore, use it, on the one hand, to reduce action or to stop action, when this is excessive; or, on the other, to bring out the action of a dormant muscle or a dormant nerve. If you find paralysis, loss of sensation, or loss of contractility in a muscle, you may, in many cases, so use

electricity as to restore voluntary movement, to restore contractility, to restore sensation. If you find pain, overaction, or spasm—whether tonic or clonic—you may so use electricity as to diminish those conditions, and bring nerve and muscle to their normal states. The mode in which you use electricity will determine the effect that you produce.

(*a*) The underaction of a muscle or nerve shows itself in either paralysis, using that term in its widest and most general sense, or in anæsthesia; or in diminished sensation—"hypæsthesia," as it is sometimes called. It shows itself also in weakness of a limb; there need not be what we call "paralysis," but the limb on one side is weaker than on the other, although it is still under the influence of the will: by a strong effort the patient may do something with it—may, indeed put all its muscles into play—but the movements are slowly produced, and are wanting in force. Still further, this condition of underaction shows itself in a relative softness of muscle and a flabbiness of limb; although if you take a tape and carefully measure it, you will find it of the same size as its fellow. You can feel a great difference, which you cannot always represent by figures: but often there is, as the expression of central disease, actual, obvious, and measurable wasting of muscles and of the other tissues of the limbs.

(*b*) The overaction, or perverted action, of a nerve or muscle shows itself by spasm, as contrasted with

paralysis; or hyperæsthesia, as contrasted with anæsthesia; or by spontaneous pain, or something which is not spontaneous pain or genuine hyperæsthesia, but which has been called "dysæsthesia"—viz., a painfulness of those sensations which are habitually unfelt when produced by ordinary impressions. For instance, when there is "intolerance of light," it is not that the patient can see better than you or I; he cannot see nearly so well, but he suffers pain during the ordinary act of vision. Do not confound this with genuine hyperæsthesia. The latter is rare, the former comparatively common; but both may be sometimes relieved by electricity.

There are, further, two conditions of the muscles which are the opposites of those I mentioned just now —viz., first, hardness of a limb, where it does not amount to actual rigidity; and secondly, actual rigidity, in which it is difficult to flex or extend the arm or leg. Further, there is tremulousness of muscle; and lastly, clonic spasm, showing itself in slight fibrillar twitching, or in catching movements of the limbs. These are all signs of an overaction that may sometimes be reduced by electricity.

As part of its effect upon muscular fibre, you must regard also the action of electricity upon the vessels. The effect on vessels is simply an extension into another region of that which I have already told you occurs in voluntary muscular tissue. There are certain contractile fibres in the walls of the vessels, and

you can influence them by electricity in the same way as you can other muscular fibres. If the vessels are dilated, as they very often are, in paralyzed limbs, you find that the skin has a dusky, bluish-red tint, and that the limb is cold. Look at the hands of a semi-paralyzed patient; you find the nails bluish-red, the extremities cold and the capillary vessels large. No part of the hand is actually white, all is dusky pink, or blue. Here electricity is useful; it contracts the dilated vessels, and induces a healthy state of the circulation in the limb, which no other means will produce so readily. You can do this, again and again, as I have said, without any electrification of the voluntary muscles. If you act on the muscles of the limb, and draw the hand of the patient first one way and then another, you may by that means gradually increase the circulation, just as the voluntary movement of the hand might have done; but without calling forth the action of any of these muscles, you can restore or much improve the circulation in the skin, by a simply superficial electrification.

It is possible that electricity might have some effect upon another condition of blood supply, just the opposite to the last—viz., that in which the vessel is contracted by the spasm of its contractile fibre. I do not know that here electricity has been of any practical service; but it is possible that, under some circumstances, it might be of use. At the commencement of an epileptic seizure, there is often a curious pallor

of the face, and to a condition analogous to this in the pia mater it is probable that the loss of consciousness is due. It is possible that if one could catch a patient going off into a fit one might stop or check the paroxysm. In those persons who are subject to sudden pallors coming over the face, it is possible that by a due administration of electricity something might be done. I know of no reliable clinical facts about the electric treatment of this kind of spasm; but in the other condition, in which you get engorged vessels from loss of contractility of the fibre, electricity has been very useful.

2. And now, what are the modes of using electricity for therapeutical purposes? Overactivity of a muscle, or nerve, or vessel, may be reduced by the application of the continuous galvanic current. This galvanic current should be perfectly continuous or constant; it should not be so strong as to cause pain; it should be so applied as not to irritate the skin; and it should be applied in such position as to include the course of the nerve.

Another form of electricity—faradization—may also be employed to reduce overactivity. If you find, for example, a man suffering from torticollis—spasmodic wry-neck—the sterno-cleido-mastoid and other muscles of one side acting most violently, and turning the head over to the opposite shoulder—you may stop that by passing through the sterno-cleido-mastoid muscle a galvanic current, or by applying weak faradization

rapidly interrupted. The interruptions have to be very rapid, for if they are not so the application only increases the muscular action. The interruption in a rotary magneto-electric machine is scarcely rapid enough, and is often very irregular; one of Stöhrer's batteries should be used. Overaction of other muscles may be reduced by the application of faradization, as well as by the continuous current; but the faradization must be weak, and rapidly interrupted. Another way in which you may reduce the overaction of a muscle is by faradizing the antagonist muscle. Supposing the flexors of the arm are contracted, as in some cases of "late rigidity," and you find it difficult to get the fingers open—the best mode of overcoming that condition is to apply faradization, not to the muscles affected, but to the other muscles, the extensors, so as to antagonize them. Again, in the case of torticollis, where a man's head goes jolting over to one side, you can reduce the overaction by putting the antagonist muscles into action by faradization, and so pulling the head round into its proper position.

By the third form of electricity, also—static or franklinic electricity—you may reduce overaction. For instance, in some forms of tonic spasm, and in painful affections of nerves, you may reduce the overaction by charging the patient from a friction machine. Thus, those oversensitive conditions of nerves which go by the name of neuralgiæ may many of them be at once removed by a charge of static electricity; and in

the same manner the electric charge may be employed for the reduction of clonic spasm, or of that tremulous condition which resembles, or passes into, the state of paralysis agitans.

When either a nerve or a muscle exhibits diminished activity, you may often recall its functions to their proper standard by the use of electricity; and for this purpose either of the three forms of application may be employed. Franklinic electricity is distinctly useful in some cases where faradization may have failed; but the interrupted galvanic current, and faradization, are those which are most commonly applied.

In passing from these generalities to details of electric treatment, I will first speak of cerebral and then of spinal lesions.

3. First, let me direct your attention to those cerebral diseases which cause paralysis; and, at the outset, request you to observe this caution in the employment of electricity. If, under any circumstances, paralysis, induced by cerebral disease, occurs suddenly, you should not use electricity at all—at any rate as a therapeutic agent—until some little time has elapsed. If you want to examine the limb, now and then, for the purpose of diagnosis or prognosis, you may use it very carefully with a low power—*e. g.*, a Weiss's battery, or some other form of galvanism. It is better to avoid faradization altogether, for you may set up mischief, or, if you do not set it up, some mischief may occur, and you may get the credit or discredit, of hav-

ing caused it. Remember that the discredit may be entirely due to you for having used electricity indiscriminately. When there is any sudden paralysis, from any cause—whether hemorrhage into the brain, or some embolic blocking up of a vessel, or some sudden congestion—it is very unwise to disturb the patient in any way; the best thing for him is to be left alone; so pray do not use electricity.

Again, when the onset of paralysis, due to cerebral lesion, is not sudden, there is one condition under which I should advise you to be very cautious how you use electricity, and that is when such paralysis is attended by pain in the head, weight of head, or giddiness of head. When these symptoms are present, it is well to postpone, at any rate for a time, electric treatment, and this although the symptoms have come on gradually. But supposing that the paralysis has come on slowly, and is unattended by any pain in the head, or by any of the other symptoms I have mentioned, you may use it, and that fearlessly; but, at the same time, you must be considerate in your mode of applying it, for, although you may be fearless about it, patients sometimes may not be so; and it is very desirable not to throw electricity into disrepute by so frightening a patient with your apparatus, or your mode of using it, that you get the consequences of fright set down to the bad effects of electricity. I have known this to occur in several instances. Young children, and even some who in regard of age are not

children, have sometimes been so frightened by the look of an electrical machine, that serious mischief has been done by the fright—mischief which the electricity used could not possibly have produced, and which has sometimes been set up when the machine has not been used at all.

I pass on now to the consideration of those cases in which you may be recommended to use electricity therapeutically, and here must redirect your attention to their varying conditions.

(*a*) First, let us consider that condition in which the contractility of the paralyzed limb, when you first apply the electricity, is good (testing the contractility, of course, according to the mode I have already described). On applying the current you find a fair amount of readiness in the response of the muscles. The patient feels the electricity, and you can see the muscles act. It need not move as strongly as the healthy limb; but it moves, and you can see that it does. There may, or there may not, be any rigidity of muscles under these circumstances; but, in either case, you do little or no good by electricity. You may diminish the rigidity, you may improve the condition of the muscle, it may become firmer, the limb may become a little warmer, the color may be more natural, that dusky blue tint that you so often find may be removed; but so far as the paralysis is concerned you may go on electrifying the patient day after day for a twelvemonth, and at the end of that time find him as

much paralyzed as he was at the beginning. That is my experience, and it is so with regard to each form of electricity. It is true also whether the paralysis of the limb be complete or incomplete. In direct proportion to the amount of contractility present is the uselessness of electricity. If the contractility be perfect, although the paralysis to the will be absolute, you can do nothing. If the contractility be retained, and be only very slightly diminished, you will very slightly improve the condition of the limb, and very slightly improve its relationship to the will.

(*b*) When the contractility is much diminished, there is much good that you may do, and you will be able to do it by working upon this plan. Use electricity—in such a form as you will select on the principle I shall mention in a moment—till you bring the contractility of the limb up to the normal standard, and, when you have done so, stop. You will usually find that the paralysis is diminished, and in some cases that it is cured. Let me remind you that it is the contractility, and not the power, of the muscle which is to be your guide, and assure you that to continue electric applications when the contractility is normal is to waste your own time, disappoint your patient's hopes, and bring electricity into disrepute.

There are two principal modes in which you may recall the lost contractility—viz., the application of the battery current, and the application of faradization; either of these will be of service, and you may

be guided in your choice between them by considerations of convenience. But supposing that you use the battery current, it must be interrupted. The continuous current for this purpose is of little or no avail.

Supposing that you want to apply *galvanism* to the arm or the leg in an ordinary case of hemiplegia, where you find the irritability less than in health. The best way to apply the electricity is by the ordinary sponge-handles; not little sponges, such as are supplied with some machines, the size of the tip of the little finger, but good-sized sponges, an inch and a half or two inches in diameter. The handles should be of such a shape that you can take two of them in one hand, which for certain purposes is very convenient. Supposing it to be the arm to which you wish to apply it, take one sponge, well wetted with salt and water, in your left hand, and put it on the shoulder, over part of the deltoid muscle; and take the other, also well wetted, in your right hand, and stroke it down the arm over the lower part of the deltoid, then down the back of the arm over the triceps muscle, and then over the biceps in front, still keeping your left hand upon the deltoid. You need not spend much time over this; a few brushings down, occupying a few seconds, are enough for the arm muscles. For the forearm, bring the upper sponge down to the hollow in front of the elbow, and then give a separate stroke to the groups of muscles over the forearm. In the early days of a case of paralysis of the upper ex-

tremity depending on cerebral causes, I should not advise you to waste time, as you would be doing, by devoting much attention to the small muscles of the hand. You may simply take a sponge and pass it down the fingers. In the lower limb you may in the same manner take one sponge and place it on the gluteal region, and with the other work down the limb. What you are doing is this: you are constantly making and breaking the battery-current through the limb by moving the sponge slowly downwards. If you were to leave it in one spot it would be a constantly continuous current through the limb. By moving it you bring the current through every point of the muscles, so as to embrace each, from one end to the other, in an interrupted battery-current; and that is what you want to do to recall the lost sensitiveness and contractility.

Respecting the use of electricity in this form, you may wish to know about the use of the inverse current in one case, the direct in another. I have never seen the slightest difference between the two, in their therapeutical effect upon paralysis; and I have compared them again and again. If the current act continuously, the physiological effect on the nerve does differ in the two cases, the current downwards diminishing the irritability, the current upwards increasing it; but the therapeutical effects of the direct and inverse currents, when interrupted and applied as I have described, do not differ. In speaking of this, let

me remind you of another fact to which I alluded some time ago—viz., that the interrupted current acts more powerfully when "direct," *i. e.*, when sent down a limb, than it does when transmitted in the opposite direction—*i.e.*, when "inverse." Supposing you found that five cells was the minimum power that would induce contraction in a limb when the current was directed down the limb, you will find that the current from the five cells, if sent up the limb, will not produce contraction. So you must remember this fact in relation to the strength of the current.

So much, then, for the mode of application of the battery-current; a large sponge, well wetted with salt and water, the upper sponge kept pretty steady, the other one moved slowly down the limb along the course of the muscles so as to embrace different portions of muscles in the current, and using a stronger or milder current according to the direction in which you send the electricity. But whichever form you use, remember that you are to use such a force as is not painful; and you are to use such a force as will produce contraction. So just stop between the two extremes; do not use so weak a current that it does nothing, or so strong a current that it is doing harm. The best guide for you, until you have had some experience of the individual upon whom you are about to apply it, is to try it on your own hand first; place it on your own hand, and use such a power as shall just to your consciousness feebly move the muscle. You find sometimes that you

are more sensitive than your patient, sometimes that he is more sensitive than you; but do not use any strength that hurts you. The painful contraction of a muscle is useless or injurious to both the muscle and the patient. Electricity should never hurt people if you want to cure or relieve paralysis. Use such a power, then, as shall be distinctly, but not painfully, felt. I think that too great importance can scarcely be attached to this. I have known electricity so applied to a patient's limb that he or she has almost fainted, and the electricity has done no good. It is wrong to apply electricity to a paralyzed limb so as to put the muscle into a state of cramp. That is the most mischievous thing you can do. Instead of waking up a natural action you put it into a very hurtful form of action.

Further, do not prolong the application until the muscle or the patient is tired. If you wear the muscle out, you do it as much harm as when you pain it. It is quite enough for you to devote a few seconds to each group of muscles, and you may repeat this process every day, or you may repeat it every other day, according to the sensitiveness of the patient. It is very much better to repeat it even twice a day, where arrangements for so doing can be conveniently made, than to continue it for such a number of minutes at a time as shall distress or weary the limb. If you find that the application of this or of any form of electricity is followed by weariness in the limb, giddiness in the

head, pain in the head, a feeling of faintness, of sickness, or a nondescript sense of discomfort about the epigastrium, do not go on with electricity at all, until such symptoms have disappeared; cease altogether for a time.

If you are about to use *faradization*, there are two or three points to be observed. You are neither to tire the patient, nor to pain the patient; therefore your application must be brief, and your current of moderate strength. You are to apply faradization with well-moistened sponges, or buttons covered with wet chamois-leather; because, otherwise, you may irritate the skin, but produce no further action. You are to apply the current to the muscles; but there is a difference in the mode of application of the faradic and the galvanic current. With the galvanic current you may place, as I said, one sponge on the shoulder and the other on the palm of the hand. Do not do that with faradization, but keep the two poles near together. It is never worth while, and never advisable, to separate them widely. It is a good rule, in ninety-nine cases out of a hundred, to hold both in one hand. There is a double reason for this; one is that you cannot then get them very widely separated; the other is, that you have the remaining hand at liberty. If you separate the two poles of a faradic apparatus widely, you are in great danger of giving the patient pain without doing him good, and of upsetting the circulation in his head. If you take a tolerably strong faradic current and

apply it to the palms of both hands, you will find very uncomfortable sensations in several parts, especially in the joints, wrist, and elbows; and if you look, you will see very little muscular action. On the other hand, if you put the two poles near together, you will find that you can put the muscles of the limb into tolerably strong action with a comparatively weak current, and without causing any pain.

In the treatment of paralysis it is important for you to bear this in mind. Take both poles in one hand, and act upon all the muscles *seriatim*. Begin with the deltoid, first acting on the anterior set of fibres, then on the middle, then on the posterior; go down to the biceps and triceps, and then faradize the upper part of the forearm. In the first few applications you need not go beyond the arm and forearm; and afterwards, when these are in a better state, it is desirable to pay special attention to the muscles of the hand. For these you want handles with rounded ends, narrow stems, and metallic buttons covered with chamois leather. Make them wet, take the two in one of your hands, and pick out the different muscles of the patient's hand separately, and especially the little interosseous muscles. By groping about you will gain a certain amount of skill, so as to be able to pitch quickly on the particular muscles that you want to influence.

You will find that in both arm and leg there are particular points at which, if you apply your current, you will put the muscles into much stronger action

than if you apply it elsewhere. Generally speaking, these points are where the nerves entering the muscles are most superficial; knowledge of anatomy will help you to find these points, but there is sufficient variation from these to make it necessary for you to examine the question electrically, and to discover for yourself, even in special cases, the points through which the current may be sent with the greatest efficacy.

Sometimes you will find curious actions which you cannot very readily explain. For example, in faradizing the peroneal muscles and the tibialis anticus, by applying one pole just behind the head of the fibula, you may, by placing the other pole above the knee, on either side, raise the heel from off the ground or the bed, by calling the psoas and iliacus muscles into action. I have seen the foot raised from eight to ten inches from the floor in this manner by a patient who could not lift the heel higher than two, or at the most three inches by the extreme of voluntary effort; and have seen it raised to a less height by those who could not, voluntarily, remove the heel from the ground. In a similar manner the arm may be raised, by the action of the deltoid muscle, when faradization is applied to the ulnar region of the elbow. These appear to be associated, or reflex movements.

Now, what do you do when you apply electricity in this way? You may restore, if it be lost, the nutrition of the muscles; you bring back their bulk. If the limb

be cool, as it very often is, from the defective circulation, you may bring back the normal temperature. When the contractility has been defective, you bring that back to its normal state, and you will find then that you have very much improved the relationship of that limb to the will of the individual—that is, you *pro tanto* improve, or it may be entirely cure, the paralysis. The mode in which electricity produces this effect, so far as we can understand it, is this. A limb has been out of use for a certain time; its muscles and nerves have lost their nutrition, and their readiness to act; and the application of electricity has quickened the circulation and restored the diminished function of those tissues. We may, I think, go still further, and affirm that, in some instances, much more is accomplished than this merely peripheral effect. By stirring up the muscles and nerves of a limb you may to a certain extent act upon the other ends of those nerves —the ends that are in the spine or head—and so you may improve, by careful usage, the nutrition of the spinal cord, or of the brain. There can, I think, be no doubt of the reality of this secondary result. It is obvious that faradization of the extremity may seriously derange the circulation in the head; and it is no less clear that its application may be followed by beneficial results which a change in the conditions of the limb will not explain.

4. There is another point to which I will now call your attention, and that is the condition of "rigidity"

in a limb in cerebral paralysis. It is common enough in old cases, and sometimes is met with in those that are quite recent. In the latter cases I advise you not to use electricity, for you may do harm; in "late rigidity," you may employ it without fear, and with considerable advantage. Here you may either remove the rigidity altogether, and also improve the contractility of the limb, or you may much diminish the rigidity, or prevent its increase. It often happens that in a case of three or four months' duration you find the flexor muscles beginning to contract, so that the patient waking up from sleep, in the night or in the morning, always finds his fingers bent, and the forearm prone, the flexure soon passing away again by a little rubbing or passive movement. After a time, although the hand may still be opened by another, it shows a constant tendency to close when it is left to itself, and at length the closure gradually becomes habitual. Now, the best way to counteract this tendency to closure is to faradize the antagonistic muscles, the extensors of the fingers, and supinators of the forearm. Under such circumstances, you need not begin at the shoulder, because contraction of the kind I have been speaking of always begins at the distal end. You do not notice rigidity of the elbow till some time after you have noticed it at the wrist, nor do you observe rigidity of the wrist until after that of the fingers has been conspicuous. Sometimes in an early stage a few applications of electricity will cure the rigidity, and

not only remove the tendency to cramp, but even bring back the proper contractility of the limb. But in more severe cases—and in those which have been of long duration—in which there is some persistent, and often progressive, lesion of the brain, you cannot cure the rigidity—*i. e.*, you cannot remove it altogether; but, even in these cases, you may sometimes do good. You may prevent it from getting as bad as it would do if left alone, and this is a very important thing to do; for, after a long time, the rigidity becomes extreme, and the patient often refuses to submit to any treatment. Then it is found that the nails have dug into the hand, and that the pent-up perspiration has become fetid and disgusting. It is impossible to prevent the occurrence of sores in some cases, except by a timely electrification of the extensors. You may often call into action the extensors of a much-weakened hand by applying a moderate faradization with well-wetted sponges to the back of the forearm, or you may use galvanization for the same purpose, interrupting the current in the manner I have described—viz., by putting one sponge on the back of the forearm over the skin well wetted, and making and breaking the current with the other hand by moving the sponge upwards and downwards an inch or two below the upper pole. But faradization is much better for this purpose than is the battery current, although the latter may be used to assist the former by applying it, in a continuous form, to the rigid and overacting muscles.

For this purpose the current should be direct; one pole, well wetted, should be placed in the hollow of the elbow, and the other in the hand. A moderate current should be allowed to pass continuously from the upper to the lower for ten, fifteen, or twenty minutes, once or twice daily, according to the severity of the case. You faradize the extensors, and galvanize the flexors of the hand and fingers; and you may, if the rigidity has extended higher, adopt a similar plan with regard to the muscles of the forearm or the arm.

5. Shaking movements sometimes occur in cerebral diseases, and may take the form of mere tremulousness, or of clonic spasm. In these cases relief may be given by two forms of electricity. It may be given by static electricity, "charging" the patient, and keeping him charged for ten minutes daily in the manner already described. Or you may pass a weak continuous current through the tremulous limb. In this case the best way of applying it is to place the patient's feet in a pan of salt and water, to put the positive pole into the water, and then let the patient's hand be placed in a basin of salt and water connected with the other pole. The current will then come up the leg and down the arm; and you will find that in many cases of tremor or clonic spasm —viz., those accompanying paralytic conditions dependent on cerebral disease—this continuous current affords marked relief.

6. Chorea.—Years ago it was said that good results

were obtained in the treatment of this disease, but I must say that, so far as my own experience goes, electricity has been of but little service. There are a vast number of cases of acute chorea that will get well if you leave them alone; and almost any form of treatment will appear to prove efficacious if it be applied to an ill or underfed child, when taken from a noisy and crowded dwelling-house to a well-ventilated hospital ward, to good food and quiet. I believe a great deal of the influence set down to electricity, ice-bags, iron, arsenic, quinine, and other medicines has been imaginary; and that the really curative agents have been those that I have mentioned. The modes employed have been as various as the forms of electricity, and each one has lauded in the treatment of chorea that particular form to which he is addicted; but in my judgment, the less one says, in the present state of knowledge, about chorea and its treatment by electricity, the better will it be for therapeutical science.

7. I pass now to the consideration of some brain affections that are accompanied by alterations in sensibility. And, first, defective sensation, or anæsthesia. Anæsthesia of a limb, or of two limbs, is very rare, except in association with motor paralysis; and then when it has occurred acutely, it usually exists only during the condition of shock. A patient, for instance, may become hemiplegic from an embolism, or from hemorrhage; and you

will find that during the first few minutes, or sometimes few hours, or, in rarer cases, days, from the onset of the attack, there may be some loss of sensibility. The loss varies in amount, but, during the condition of shock, may be occasionally well marked. After that condition of shock has, however, passed away, the sensibility commonly returns; and, so far as electrical treatment is concerned, all that I have to say is that during the period of shock, it would be very unwise to use any form of electricity. Sometimes there is partially impaired sensibility persistent when the phenomena of shock have passed away, and in such cases faradization with the metallic brush is often very useful. The brush should be passed briskly over the affected skin with one hand, while the other maintains a well-wetted sponge at the upper portion of the limb.

In certain brain diseases of slow development you may find persistent loss of sensibility: but these are, comparatively speaking, rare. You every now and then meet with some portion of skin defective in sensibility, from a tumor in the head or some other cause. But it is much more common for you to find some modified sensibility, such as the feeling of "pins and needles," or painful impressions when the skin is touched. In those cases of acute cerebral disease, however, in which you do find persistent anæsthesia, or even only diminished sensibility, it is very rare for you to find that electricity does

any good. It may do harm, and I should advise you not to use it unless the case were of such sort that you used it only for the purposes of diagnosis, and then only in such a form as should enable you to feel quite sure that you can do no mischief.

The examples of anæsthesia in which electricity is most useful are to be found in that curious class, or rather medley, of cases that go sometimes by the name of "hysterical;" for they are generally met with in women, and are found together with symptoms of the kind commonly regarded as hysterical. Here you meet with marked anæsthesia of the skin in different parts of the body, almost always associated with a certain amount of awkwardness of movement, and sometimes associated with some very definite loss of power. The two often go together, for both the apparent power of movement and the actual power of combining movements are distinctly related to the integrity of guiding sensations derived from impressions made upon the skin. Cases of this kind last often for months or years; the movements of the body or of certain limbs are weak and clumsy; patients, finding it awkward to use their limbs, cease to do so, and, from disuse the muscular power becomes defective; there is also some failure of nutrition and diminution of electric contractility. I have seen an interesting case, of many months' duration, in which there was paralysis, anæsthesia, and great coldness of the limb—the left leg, from the

middle of the thigh to the toes—the difference in temperature between it and its fellow being not less than 10° to 12° Fahrenheit, which was completely cured, and that after four applications, by faradization. There was little of the ordinary "hysteric" appearance in this case, and the temperature difference was marked and persistent; still there was no failure of nutrition, and I could not refer the patient's illness to any other category. The improvement was immediate, and the cure has been persistent. Patients of this kind are often bedridden or very nearly so; but in their case electricity proves wonderfully useful; for often, after only a few applications, the sensibility and motility have been restored completely. Electricity should here be employed in such manner as to produce a definite and distinct impression on the skin. Supposing there is anæsthesia of the skin of the leg, place one pole of a faradic apparatus in the patient's hand, attach to the other a dry metallic brush, and pass it quickly and lightly over the surface of the skin. In that way you send in a number of little bright sparks, which you may hear, and also see very plainly in the dark, and you sting the skin very briskly. Or you may take a charcoal conductor, or a metallic conductor, and move it up and down on the surface of the skin. In the first few moments perhaps the patient does not feel it, but you now and then find the sensibility of the skin return with marvellous rapidity. Sometimes

you find it is a better plan to take two thoroughly wetted sponges and a tolerably strong current, and so apply it as to make the muscles act briskly. By so doing, in the course of few minutes the skin will often recover its sensibility. I am not able to explain thoroughly why this should be, but I have seen it again and again, and have observed it even after the application of the brush has been made without success. An analogous condition is that in which the skin retains its sensibility while the muscles have lost their contractility, and in which by stinging the skin you will sometimes restore the muscular contractility. These facts have an interesting relation to each other. In facial paralysis, by stimulating the skin, either by electricity or by a blister, you may often bring back the muscular action very speedily. Where there is a loss of sensibility of the skin, the muscles acting tolerably well, you may by putting them into forced action restore the sensibility of the skin; and it is most likely that what one does under these circumstances is to stimulate that which is common to both muscle and skin—viz., vessels; and further, that, in thus acting on the skin, we exert some influence on the nerve-trunks, and also on their central extremities, by reflex action.

You may accomplish the same end by franklinic electricity, by directing sparks from a prime conductor to the part affected, or by "charging" the patient, and taking sparks away from the surface by your

knuckle or a brass ball. The effect of this application is that, in a little time, you redden the skin, and restore the sensibility. In extreme cases you may go still further, and apply a moderate charge from a Leyden vial. For instance, you may inclose a limb between the knob and the discharging rod, and let the shock go through it. This will sometimes bring back the sensibility when other means have failed.

In all cases of *hysteric* paralysis, whatever may be the distribution of the symptoms, electricity is of the highest service; and faradization or franklinism are found to be much more efficacious than galvanism. The mode of application is the same as that which has been described for the graver lesions. When the nutrition of limbs has failed from disuse, then the continuous current is of especial service.

8. There are two classes of spinal diseases to which I have already alluded, in one of which you have the true "spinal paralysis" of Dr. Marshall Hall; in the other of which you have "cerebral paralysis," although depending on spinal disease. In the one the muscles derive nothing from the cord, because the latter is diseased or destroyed; in the other the muscles are still associated with the cord, though that cord may be cut off from the brain.

(*a*) First, let us take the case of the true spinal paralysis. What can you do there electrically? The damage done to the cord is to be measured by the loss of electric irritability, and as a rule to any form of

electricity that you employ. If the electric irritability, in a case of this kind, be absolutely gone, and show no sign of reappearance after four or six applications, your prognosis is bad, and there is little or nothing to be gained by a persistence in the treatment.

When you find a certain amount of contractility remaining there is a great deal to be done. You compare the limbs of your patient with the healthy limbs of some one of the same age and sex, same class of constitution and thickness of skin, and if you find contractility diminished somewhat, but not lost, there is much room for hope; and a great deal will depend upon what you do as to the upshot of the case in the future.

Take, as an instance, the case of "infantile paralysis" (so-called "essential paralysis" of children)—one of the best examples you can have. A child is a little feverish for twenty-four hours; you find it cannot sit up, cannot move its arms or legs for a few days. Then it begins to move one arm a little, and perhaps one leg; after a day or two more, perhaps both arms. If you do not notice it again for a week, you may find one limb completely paralyzed and the other partially; the distribution varying. Post-mortem examination in such a case shows very often disease of the spinal cord itself, running along its whole length; a disease which, when left to itself, eventuates in the destruction of the tissue of the spinal cord; producing in the first instance true spinal paralysis, and in the last instance perfect

spinal paralysis also, but the former curable, the latter perfeetly ineurable. In the early stage you find a certain amount of eontractility left, but it is very defeetive. Here very mueh may be done by eleetrieity. You find also this eurious point, that the muscles respond much more readily to a slowly interrupted current than to a rapidly interrupted eurrent. To faradization you find them defective, and sometimes you eannot get them to aet at all. If you interrupt the battery current very rapidly, they sometimes will not aet to it; but if you interrupt it slowly, you find that they do. And what is very interesting about these eases, and to which I have already alluded, is this: that the museles sometimes appear to act more readily than those in health to a very low eurrent of galvanization. Here, probably, the eondition is a eomplex one, and to sueh eases the battery eurrent, slowly interrupted, should be applied every day for a few minutes, not troubling yourself, at first, about partieular groups of muscles, but just applying it to the whole limb. If it is the leg, put one of your sponges either on the saerum, just below the groin, or in the gluteal region, and move the other sponge slowly down the back of the thigh and along the surfaee of the leg. You often find, under sueh circumstances, that after a day or two you have to use a stronger power to produee the effeet that you produced at first; and you will find at the same time that the muscles respond more readily to faradization. It is well then to

change, and employ faradization instead, using it with sponges well wetted, trying to pick out particularly certain sets of muscles which have a trick as it were of lagging behind the others. These are, especially, the extensors of the foot, the peronei, and the extensors of the fingers. Here, then, you may apply faradization; and if the disease in the spinal cord be curable, I am sure you assist the process of cure. If the disease had existed for some time before the case is brought to you—and cases are often brought after three or four years' duration—you will still find that occasionally you can do something. For example, the action of the fingers may be rendered a little less clumsy; or the extensors of the foot and toe may be so far improved that the great toe drags less upon the ground in walking. You may call into exercise the muscles of the limb; you can improve their nutrition and their strength; and you may do something towards effecting a change in the nutrition of the cord itself. Where, however, the disease has lasted for some time, I have not seen that the repeated use of electricity has done much good, unless some improvement has been apparent at the commencement of treatment. You may see some enlargement of muscles, but there the improvement ends. When you find that, after four or six applications, there is no sign of electric contractility either by the induced or the battery current, it is useless to go on. I have managed every now and then to have cases treated for many months, with the forlorn hope that at some period or another there

might be a ghost of contractility returning, but I must say it has been utterly unsuccessful.

b. Let me now direct your attention to cases of paralysis, dependent upon spinal disease, in which there is not any true "spinal paralysis;" for the muscles still retain their connection with a healthy portion of the medulla, although, owing to disease at a higher level of that medulla, they are completely paralyzed to the will. In these cases electricity can accomplish but very little, and yet that very little may be of considerable service. Every now and then a certain group of muscles especially suffers; the sphincters of the bladder and rectum are very prone to be deranged. Sometimes the expulsive power is affected, sometimes the retentive. It occasionally happens that, although you cannot in the smallest degree affect the limbs of the patient, you may give the patient a little more power over the sphincters. Probably their nutrition has failed, and the condition is something like that which I have already described. You may bring back power enough to make the sphincters competent; and to do this is to afford great relief. If you want to apply it to the sphincter of the bowel, the best plan is to put one sponge of the faradization machine over the sacrum, and the other, well wetted, to the anus; and if you want to apply it to the sphincter of the bladder, you place one sponge, well wetted, on the perineum, just behind the scrotum, and the other over the symphysis pubis. By such means you may prevent the frequent invol-

untary passage of evaeuations. I do not say that you will do it in all eases, but you will in some.

But, again, you get eases in whieh the disease of the spinal eord is sueh as to produee only incomplete paralysis. The limb is weak, the contractility is less than natural, and the nutrition is disposed to fail. Can electricity do anything there? I think it may do a great deal. These constitute the class of cases in which it does very much good. But here you must observe the caution I gave you in the last lecture, not to use too strong a eurrent of electricity during the early days of an aeute illness. If you suppose the patient to be suffering from the effeets of a reeent myelitis, meningitis, or hemorrhage into the eord, it is a very foolish thing to galvanize him. If, on the other hand, disease is creeping up slowly—*e. g.*, white softening or ehronie myelitis, or paralysis dependent upon syphilitic meningitis that may have occurred some time ago and led to some slowly induced pressure on the cord, you may, in sueh eases of partial spinal paralysis, find electricity very useful.

Here it is that I would especially distinguish between the faradie and the battery eurrent. Where there is wasting of the limb, the application of the battery eurrent has appeared to me much more efficaeious and mueh less misehievous than the other, when it is applied in the manner I have deseribed. Where, on the contrary, there has been no such

wasting of limb, it seems to me that faradization has acted better — faradization applied with wet sponges and especially directed to the muscles. If the contractility of a muscle is good, and just in proportion as you find the contractility of a muscle good your prognosis is bad, so far as electrical treatment is concerned. If you find, for instance, a limb perfectly paralyzed, but contracting perfectly well to galvanism, or sometimes acting even in excess, you can do nothing more by applying galvanism to that limb. Your prognosis may, however, be good if you find the contractility diminished but not lost. If it be wholly lost, the prognosis is bad; if absolutely good, the prognosis is bad; if between the two, it is in proportion to the improvement you can effect in the nutritive condition by one or two applications of the current.

I have to mention only one other point in these cases of spinal paralysis,—cases of impotence. These cases are sometimes very much improved by the use of electricity applied in the same manner as for loss of power over the sphincter vesicæ.

9. Paralyses from injury to or disease of the nerves—the third group—are distinctly of the same class as those which Dr. Marshall Hall called "spinal paralysis." Some persons have called them "peripheral," "local," or "traumatic" paralyses. So far as the contractility of the muscles is primarily concerned, it matters not whether you cut the nerves

across or destroy the cord to which those nerves were attached. If you divide a nerve going to a muscle—as, for example, when the facial nerve is divided by disease in the bone—you have "spinal paralysis" of the facial nerve in the sense in which Dr. Marshall Hall used that word. The severance of muscles from the spinal centre may be complete or incomplete, and you can measure the amount of separation or of damage done by the amount of electric contractility that remains. If a muscle or a group of muscles has been for a time completely paralyzed by damage done to a nerve or by neuritis, and yet the morbid state of the nerve was of such kind that it might be repaired, then, although the nerve has recovered, the results of its disuse may remain, and imperfect paralysis may persist. For instance, take this example, which occurred not very long ago. A man tried to lift a heavy portmanteau, strained himself in doing so, had great pain in his arm afterwards, and then most intense, indeed agonizing, burning and tingling in the tips of his fingers and palm of the hand. After a time the pain disappeared, and then it was found that his hand was excessively weak and that the muscles were wasted. He had strained his forearm, injured its nerves, and set up some neuritis; but after the neuritis passed away, there remained paralysis of the muscles, with wasting, and almost complete loss of electric irritability. It was not until some time after all these symptoms had occurred that he was treated electrically, and then the diffi-

culty to be contended with was the wasted muscles. In looking at what he could do with his hand, we found that there was every movement of the hand that could be performed. He could bend all his fingers, separate them, and bring them together again; but he could not do this quickly, nor could he do it forcibly. There was partial paralysis of all the muscles of the hand, depending upon damage to the nerve, and also upon consecutive changes in the muscles. Electricity was applied to the forearm and hand, and the muscles soon improved in their nutrition; and with that improvement in the nutrition of the muscles the voluntary power returned. You may find a similar thing now and then in the case of facial palsy—paralysis persisting as the result of past disease. Examined electrically, you find that there is a certain amount of contractility left, although it is defective. If you apply electricity after an interval of two or three weeks, you may often cure the case by a very few applications; but if the paralysis has lasted for six months, you will find at first very little contractility indeed, and you will have to apply electricity again and again before you obtain any distinct marks of improvement. Sometimes there is slight restoration of voluntary power after even the first or second application, and then the subsequent improvement is very trifling. When the paralysis is imperfect, and the contractility is only diminished, you may accomplish much; but when the contractility

has quite disappeared there is little or nothing that you can do. You never can tell until you have made several applications of the current, whether or not the case is curable; for although a group of muscles may be completely paralyzed to the will, there may be some few nerve-tubules that have escaped destruction, and their functions may be slowly recalled.

The mode in which you should apply electricity in cases of local paralysis is the following: Place one conductor, well wetted, over the trunk of the nerve, and the other over the muscles, *seriatim*. If you are using faradization, you may keep the second conductor steady; if galvanism, you must move it about, in order to interrupt the current.

Paralysis of the third nerve, with ptosis or strabismus, may be treated by galvanism or by faradism; in either case one pole should be placed behind the ear, in the hand, or on the cheek-bone, and the other should be applied to the lid. A weak current should only be used, and the application should be brief.

In paralysis of the seventh nerve, from simple exposure to cold, the best plan of using electricity is the electric brush. Place a well-wetted sponge behind the ear, and take the metallic brush, and brush it over the skin so as to sting the face. If it have existed longer, and there be much wasting of muscle, the same rule applies; but here you should also operate upon the muscles; and I would advise you to use the battery current for a certain number of times, until you find that its

power of eliciting contraction diminishes, and then to apply faradization.

10. And now a word or two about other kinds of paralysis depending more or less on some morbid condition of blood, or nerve, or muscle, or of all these elements together. And, first, let me direct your attention to poisoning by lead.

(*a*) I do not know the precise mode in which lead produces paralysis, or why it singles out particular muscles; but in those muscles which are affected, it is found that there is undue readiness of response to a slowly interrupted galvanic current, and greatly diminished contractility to faradization and to a rapidly interrupted galvanism. Whatever may be the explanation of these points, remember that it is not simply a question of difference in the kind of electricity applied; for if you rapidly interrupt the battery current, you find the muscles in lead palsy do not act to that. The rapidity of the interruption may account for the inaction of faradization; but why the muscles that are paralyzed should act more readily than healthy muscles to a slowly interrupted current has not yet been explained. The mode of treating lead palsy has been by faradization, or by the application of the battery current. You take a current from, say, five cells, apply it to the extensors of the hand, and you produce definite contraction. After a few applications you often find that five cells are not enough, you have to use seven or eight or ten; and in a few weeks of ap-

plication you have to use quite as many to produce contraction as in a healthy limb. At first they are very sensitive to the battery current; then gradually as you apply it, they grow less so, and you then, curiously enough, find them brought back into their normal relationship to faradization. There is no doubt about the fact that the improvement in nutrition, which seems to be brought about by the battery current rather than by any other means, entails a loss of the morbid irritability to that battery current, and with that improvement in nutrition you get a return of the normal contractility. If you have not a battery current, you may use faradization to begin with; but if you do, be quite sure that you affect the muscles. I have known patients with lead palsy treated by having their hands in water and their feet in water while the current is passed from one to the other. Such a proceeding is not of the slightest good. If you were to apply one pole of a faradization machine to the chimney-pot of a man's house, and the other to his doorstep, you would be about as likely to get the current into the muscles that you want to benefit! You must apply faradization locally, with thoroughly well-wetted sponges, and of such low intensity that it is scarcely felt, and yet of sufficient strength for you to be certain that the muscles respond. Use it every day, and have particular muscles singled out—just those which are the most paralyzed. In these cases it is often difficult to get the current into the limb; and

you will find an advantage sometimes in soaking the limb, or covering it, for an hour or two beforehand, with wet lint and oiled silk at the spots where you want to apply the sponges. Get the skin well moistened, and the current will pass through more readily.

(*b*) One word about the paralyses that come from anæmia, and are often met with in pale, hysterical girls. Some are set down as hysterical without, I think, any just cause; they are more or less dependent probably on an altered blood state, which may affect the cerebral centres, and lead to these peculiar weaknesses. I am quite sure that some of these local paralyses are relieved occasionally by static electricity administered in the mode I have described already, by sparks applied to the skin from the prime conductor, or by a shock from the Leyden vial. One of the forms which anæmic paralysis occasionally takes is that of loss of speech, or change of voice, dysphonia, or aphonia. It is often called "hysterical" aphonia. It may be hysterical, according to the use of the term by some people, but in many cases it exists quite alone and apart from anything that one ordinarily recognizes as the hysterical temperament. When present there is almost invariably marked anæmia. Here sometimes a few sparks from the prime conductor of a machine will bring back the voice directly. Sometimes, if that will not do, the Leyden vial will immediately succeed, and this after you have applied electricity in other forms without success. A few sparks do not cause

pain; but if you apply faradization to the larynx, you do cause a great deal of pain. It is uncomfortable to have even a weak faradic current passed through the larynx, and it is often perfectly unsuccessful; and yet a spark, which causes no distress, will often bring back the voice at once. In certain cases it is desirable to introduce the current of faradization into the glottis; and this is so when there is distinct paralysis of the vocal cords. You may see with the laryngoscope that one or the other cord, or that both cords, are paralyzed; and it is quite easy to apply faradization to the larynx internally in the manner recommended by Dr. Morell Mackenzie. One pole is held in the patient's hand, or applied to the nape of the neck; the larynx is well exposed; and the other pole is carried between the cords by an instrument constructed for this purpose. This is shaped like a catheter, with a small sponge at the end; and this sponge has a wire passing from it inside the catheter up into the handle, which is so connected with a key that you can either make or break the current by pressing on the key. Having placed the sponge in between the vocal cords, you touch the key and send the current between them. Patients will sometimes cry out the moment that the application is made, as you may very easily imagine that they would if they have any crying power left in them. But many patients prefer the internal faradization of the larynx to the external, affirming that it is the less painful of the two.

11. There are a few words only which I wish to say about local spasms. The forms of spasm in which electricity has been most commonly used are "torticollis," a spasmodic condition of the muscles of the neck on one side; "writers' cramp;" and so-called "histrionic spasm" of the face. It is said that such cases have been cured, but my own experience has been unfortunate with regard to them. I have tried electricity again and again, and in every available form, but have never seen it do any good. I have tried battery currents, direct and indirect; I have tried faradization weak and faradization strong, with wet sponges and with dry; I have used static electricity also, and each form of electricity persistently; I have not given up because the treatment has done no good at first; but I do not know one single instance in which it ever seemed to me to do the smallest good. In tortieollis, for the time being, you can put the head straight by either a strong battery current passed through the contracting muscles, or by faradization of the other side, the muscles of which are often weak; but directly you cease the application the head goes back again into its abnormal position. I have obtained similar negative results in cases of both writers' cramp and histrionic spasm. Others have been more successful, and I trust that your experience may resemble theirs rather than my own. Since the first edition of these Lectures was published, my friend, Dr. George V. Poore, has treated cases of writers' cramp and scrive-

ners' palsy successfully by a process peculiar to himself. Dr. Poore has found some muscles defective in irritability, and others overirritable. The plan which he has adopted has been highly ingenious and useful —viz., the faradization of weakened muscles, and the application of a constant current to muscles disposed to spasm, together with the employment of rhythmic movements of the limb, at the time of the latter application.* From my own knowledge of some cases which Dr. Poore has thus treated I can speak with much confidence and hope as to the future of many forms of this disease, which had previously proved so intractable as to lead to the general expressions which I have used on the preceding page.

12. In painful affections, such as the neuralgiæ, migraine, sciatica, tic douloureux, and the like, and also in some conditions of modified sensibility, such as the spontaneous feeling of heat or cold, the sense of numbness, of tingling, "pins and needles," or such like discomforts, electricity is often of considerable service. It is the continuous galvanic current which you should use, and it should be of only such strength as to be just perceptible by the patient; it should be applied to the part with well-wetted sponges, and should be applied for a short time only, but with frequent repetition. I know of nothing more distinct or more satisfactory in therapeutics than the relief which may often thus be given to suffering of the most intense charac-

* See the "Practitioner" for 1872–1873.

ter, the relief being very rapidly indueed, and in many eases permanent. In applying galvanism to the head you must be very careful to avoid using sueli a strength as to cause vertigo or faintness, and I am sure that you may avoid these evils by trying the eurrent upon your own head first, and then by earefully observing the patient, and stopping the application for a time the moment that there is any eomplaint, by word, gesture, or look, of any uneasiness in the head or epigastrium.

Franklinic eleetrieity may be used advantageously with the same object; the patient being simply "eharged," or having sparks, when eharged, taken from the painful part.

In some cases of disease it has appeared that good results have followed the applieation of the eontinuous current to the eentral organs of the nervous system, the brain and spinal eord; and in other easés benefieial results have been witnessed after the galvanization of the sympathetie nerve; but the evidenee upon these matters is of such sort that I think it better merely to allude to the applieation than to deseribe its method in detail.

Eleetrieity is one of the most powerful agents that you ean employ in the treatment of disease; but it is useful, useless, or misehievous, aeeording to the manner in which it is applied; and my endeavor has been to furnish you, by means of these leetures, with the information which shall enable you to derive help from it in diagnosis, and eonfer real advantage upon your patients by rightly direeting its therapeutie powers.

APPENDIX.

ON THE REQUIREMENTS OF AN "ELECTRICAL ROOM."

A COMPLETE "Electrieal Room," for hospital or private use, contains the following apparatus:

I. *Franklinic Electricity.*—1. A eylinder or plate maehine, the latter being mueh the more useful. *a.* The eylinder should be at least a foot and a half or two feet in length, and ten or fourteen inehes in diameter; and it should have a multiplying wheel for turning, so that the rotations may be rapid. *b.* The plate machine should be at least eighteen inches in diameter. 2. Brass chains, or strands of eovered flexible wire, should be in readiness to eonneet the patient with the prime eonduetor, or to attaeh the direetor for the administration of sparks. A thin flexible eopper wire has some advantage over a chain, inasmueh as the sharp edges of the links in the latter waste very much of the electrieity that is employed. 3. A large glass-legged stool, upon whieh a chair ean be plaeed at pleas-

ure; or a sofa with glass legs; or deep cups of glass into which the legs of a sofa may be placed. The sofa should be covered with leather, and not with stuffed or woollen material. 4. A director—*i. e.*, a brass knob attached to a glass handle by a strong brass wire, to which the electricity may be conveyed from the prime conductor by the wire or chain mentioned above (2). 5. A Leyden vial, eight inches by four, or larger. 6. A discharging rod, with glass handle and flexible joints. The most important point to attend to in the care of this apparatus is freedom from damp and dust.

II. *Galvanic Electricity.*—The apparatus for galvanism is so varied in form that I only mention those batteries which will be found the most generally useful. 1. The Battery. That made by Messrs. Weiss has advantages of portability, constancy, regulation, and strength. It occupies but a small space, and is readily put into or out of action. The constant battery of Stöhrer is also very convenient, but is more bulky than that of Weiss. The apparatus of Messrs. Elliott is admirable in many respects, but it occupies much space, and is not conveniently portable. Mayer and Meltzer's instrument for both galvanism and faradization is ingenious and portable. At University College Hospital we have in the electrical room a battery of one hundred cells, which is a fixture; we have also a battery of fifty cells placed on castors, so that it can

be wheeled to the bedside of a patient. 2. Handles for the application of the current. These should be of good size, capable of holding sponges at least three-quarters of an inch in diameter; and it is well to have handles of even larger dimensions. 3. Wires, covered with silk or gutta-percha, to connect the handles with the poles of the battery. These may be in several series, and it is a great convenience to have a pair of wires of four or six yards in length, in order to reach a patient at same distance. 4. An interruptor may be sometimes useful, but it is by no means necessary. The battery should be put out of action when not in use. The handles should be kept scrupulously clean, and the sponges taken out of them when the application is over. This is especially necessary when the sponges are held in metallic cups; but is not so important when the cups are made, as they have been by Messrs. Weiss, of vulcanite with attachments of platinum wire.

III. *Faradization.*—1. The Battery. This may be found in very many forms, but the most convenient battery for general use is that of Stöhrer. It may be procured with either one or two cells; the latter is to be preferred when the use is very frequent. 2. Handles for application. *a.* A pair of handles with dry carbon points. *b.* A pair of handles with sponges of half an inch diameter. *c.* A pair of handles, known as Duchenne's, with button-shaped ends, covered with

chamois leather. *d*. A bent probe-shaped handle, covered with leather at the end. *e*. A brush of metallic wire. 3. Covered wires of varying lengths, as described for use with galvanism. These batteries should be put out of action when not in actual use, and great care should be taken to protect them from shaking, blows, or strains, which may disarrange their automatic movements.

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